SCIENTIFIC AMERICAN SUPPLEMENT. No. 1629

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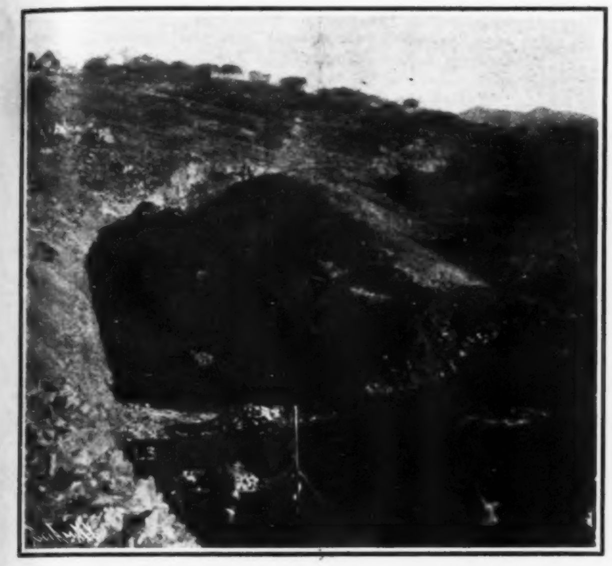
Scientific American, established 1845.
Scientific American Supplement, Vol. LXIII., No. 1629.

NEW YORK, MARCH 23, 1907.

Scientific American Supplement. $5 a year.
Scientific American and Supplement. $7 a year.



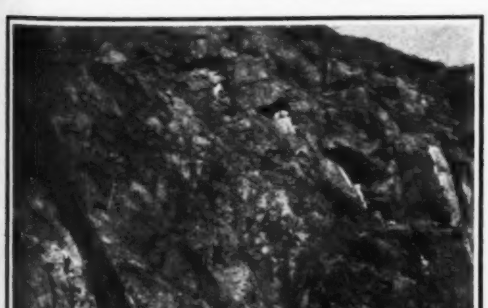
A CUTTING NEAR THE TOP OF THE DIVIDE.

THE ROAD THROUGH THE LOWER PART OF THE LENGUE GORGE.

CUTTING IN THE FACE OF THE CLIFF AT THE UPPER END OF THE RACK SECTION.

WORKING ON THE ROCK FACE AT THE RAILHEAD.

COMPLETING THE EARTHWORK FOR THE LENGUE GORGE RACK SECTION.



A HEAVY CUTTING THROUGH THE ROCK OF THE LENGUE GORGE.

SINGLE SPAN STEEL ARCH BRIDGE ON THE 1 IN 16 RACK SECTION.

A NEW TRANS-AFRICAN RAILROAD FROM THE ATLANTIC SEABOARD TO LAKE TANGANYIKA.

A NEW TRANS-AFRICAN RAILROAD FROM THE ATLANTIC SEABOARD TO LAKE TANGANYIKA.

By the ENGLISH CORRESPONDENT of SCIENTIFIC AMERICAN.

ONE of the most important undertakings in connection with the development of transportation facilities in the African continent, and second in magnitude and character to the Cape to Cairo Railroad only, is a new line that is being carried in a transverse direction across the Dark Continent, from the Atlantic seaboard to the southeast corner of the Congo Free State, and to the country around Lake Tanganyika. This road is the outcome of the discovery of the incalculable mineral deposits that has been made in the Katanga country and which comprise all the most important commercial metals of to-day, such as copper, tin, iron, gold, silver, etc. These are all found to exist in abundant quantities.

THE VIADUCT NEAR THE ENTRANCE OF THE LENGUE GORGE.

Owing to the peculiar geological formation of the earth's crust in this region, the mineral lodes are found practically on the surface, and will consequently prove inexpensive to work by the company which has secured them, the Tanganyika Concessions, Limited; while owing to the richness and amplitude of the coal deposits found in the immediate vicinity, the fuel question, which plays such an important factor in the economical development of a mineral district, will offer no serious difficulties. Evidently this region constituted the El Dorado of the ancients, since there are evidences of long-since abandoned workings on every side, where the mineral veins have been worked in galleries and caves. This country, which spreads over an area of several hundred square miles, will shortly be penetrated by the Cape to Cairo Railroad, and will thus be brought into direct communication through Buluwayo with Cape Town, Delagoa Bay, and Beira. The absence of railroad facilities has appreciably delayed the mining development of the country in the district. At the present time, owing to the fact that communication between the Tanganyika region and the coast is confined to the slow and uncertain, as well as expensive methods of animal transport, the cost of conveying material to and from the mines is high, the average price being $410 per ton. Even when the railhead of the Cape to Cairo road reaches the country, the long distance separating the region from Cape Town—some 2,650 miles—would somewhat militate against the cheap and quick transportation of the products to the markets of Europe.

In view of these circumstances, Mr. Robert Williams, the well-known South African mining engineer, proposed to his company, which has acquired the rights to exploit the mineral deposits of the country, that a line should be built from a convenient point on the Atlantic seaboard, stretching transversely across the country to Katanga, at or near which point the line would effect a junction with the Cape to Cairo trunk road extended northward from Buluwayo. In this way the railroad journey would be limited to about 950 miles—about one-third the distance *via* the Cape—while the sea journey to Europe would also be reduced by one week, so that altogether two weeks' time in transit would be saved. Preliminary investigation showed that the most advantageous route for such a railroad would be through the Portuguese West African colony of Angola, following the highlands of the great trans-African plateau or "Divide," since thereby comparatively few engineering difficulties would be encountered, while moreover it would be possible to proceed in almost a straight line from the seaboard to the interior terminus of the road at Katanga. Mr. Williams approached the Portuguese government, before whom he laid his project, and the latter realizing that such a railroad would serve to open the immense rubber trade of their West African possessions, immediately granted facilities for the construction of the road. A strip of land 100 miles in width was conceded across the Portuguese territory within which the line was to be laid.

LOBITO BAY, SHOWING HOW THE LAND DROPS SHARPLY INTO THE SEA.

For some eighteen months construction work has been vigorously maintained upon the first section of 200 miles stretching from the coast. In this section the greatest engineering difficulties are being encountered, since a climb to the summit of the "Divide," about 5,000 feet above sea level, has to be made. The engineers in charge of the scheme are Sir Douglas Fox and partners and Sir Charles Métcalfe, who are also carrying out conjointly the Cape to Cairo scheme. The later enterprise, known officially as the "Benguella Railroad," is being carried out upon the same scale as that proceeding from the Cape to Cairo in regard to gage, rolling stock, and other factors, so that an ordered uniformity and standardization of the systems may be insured, inasmuch as the Benguella railroad will be connected with the Rhodesian systems, so that joint communication and running powers over the respective roads may be possible. Mr. Edward Robins, who was formerly associated with the government railroads of the Gold Coast, is the resident engineer, the work of construction being carried out by Messrs. Griffiths & Company, of 62 London Wall, London E.C., under the supervision of Mr. Norton Griffiths, who has been identified with several prominent engineering projects of a similar nature in America and other parts of the world.

One of the first phases of the undertaking has been the formation of a new harbor at the seaboard terminus of the railroad. The most important Portuguese port on the Atlantic coast is Benguella, but the anchoring and other facilities existent at this port were deemed to be entirely inadequate. The port is exposed to the full fury of the Atlantic storms, and sufficient protection to the anchorage could be assured only by the construction of breakwaters, piers, and other elaborate works, which would have entailed great expenditure. However, some 20 miles farther north there is a large natural harbor, Lobito Bay, which upon being surveyed was found to afford excellent facilities for anchoring purposes. There is a tongue of sand about three miles in length which juts northward into the Atlantic, sheltering behind it a broad sweeping bay some three miles in width, and entirely landlocked except for a single deep passage at the entrance. The tide exercises a peculiar effect upon this bay, sweeping around the land on all sides and dredging or scouring the bay without eroding the sand spit, so that the shore drops perpendicularly into the water. So efficient is this tidal action, that even at low water a mail steamer of 6,000 or 10,000 tons can anchor beside the land, and the passengers can step directly off the vessel onto the shore over a 15-foot gangway. Consequently, the erection of longitudinal piers or quays has been rendered unnecessary, though for convenience a substantial timber jetty has been erected to carry the railroad at the same level as the steamer's decks. The geological formation of this spit is peculiar, for although it is entirely constituted of sand, offering a hard, level, and closely-packed surface, and is utterly devoid of vegetation, yet at a depth of about 10 feet plenty of water, which is brackish only, can be found. Owing to the immense advantages offered by this port as compared with the dangerous inadequacy of Benguella, the latter is rapidly falling into desuetude, the sea-going traffic being diverted to the new port at Lobito Bay, where a flourishing town is rapidly coming into existence.

Though the old port of Benguella has thus been abandoned, the railroad makes a short detour southward to that town, so that it is brought into communication with its rival, before deviating toward the interior. This 22 miles of track did not present any serious engineering difficulties, as the country is of fairly level nature in its configuration beyond the spanning of the Catumbella River. The bridge thrown across this important waterway is of the open lattice girder type, comprising a single span 250 feet in length by 12 feet wide; it provides communication between the opposite banks for vehicular and pedestrian in addition to the railroad traffic. The track is of 3 feet 6 inches gage, in accordance with the South African standard as already mentioned, with curves of 328 feet minimum radius, while the heaviest gradients, except on the rack section, are 1 in 40. The steel rails are of the 60-pound per yard type, laid on pressed steel cross ties—the ravages of termites preclude the utilization of wood for this purpose—of trough section and weighing 70 pounds each. The road is ballasted with coarse sand, gravel, or broken stone, according to which is the most conveniently obtainable. As several sandy stretches have to be crossed within the first fifty miles, and the sand encountered is coarse, clean, and sharp, and packs well and firmly, it has been utilized for ballasting at these points and has been found to stand heavy traffic remarkably well. The road is bal-

THE SUMMIT OF THE DIVIDE, SHOWING THE FLAT TOPOGRAPHY.

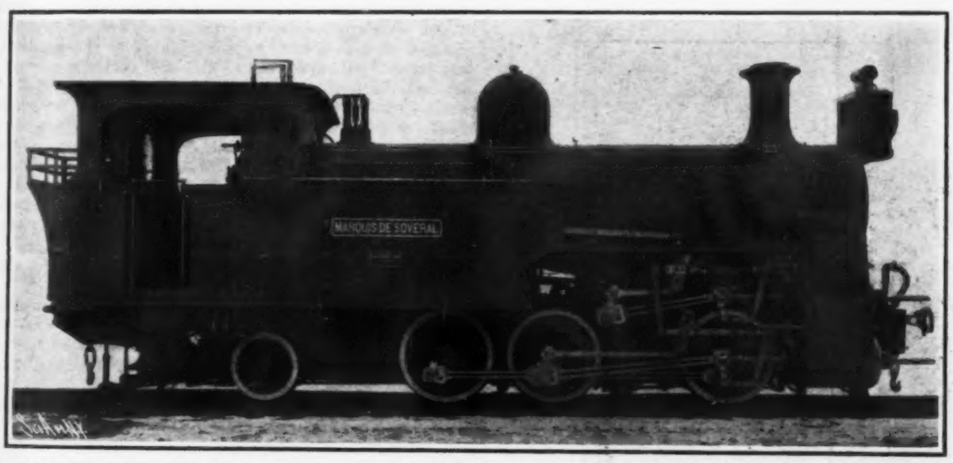
SINGLE SPAN BRIDGE ACROSS THE CATUMBELLA RIVER.

A NEW TRANS-AFRICAN RAILROAD FROM THE ATLANTIC SEABOARD TO LAKE TANGANYIKA.

lasted to a depth of 11 inches below rail level in all cases.

Between Lobito Bay and Benguella, the negotiation of the sandy stretches occasioned some difficulty. In this region the same peculiar feature prevails that exists in the Nevada desert, where the Humboldt River empties itself into the desert and becomes lost in the sand, forming the famous sink. The many tributaries flowing toward the Catumbella River never reach their outlets, but become lost in the extensive waste of sand. Consequently the laying of a railroad across such stretches was faced with considerable difficulty, owing to the treacherous nature of the unstable soil. Notably was this the case at Cavaco. At this point, although the sand is superficially substantial, at a depth of 10 feet or less abundant quantities of brackish water were found. Therefore the road had to be carried upon a low steel girder viaduct 525 feet in length and built in eight spans of 65.63 feet each, supported on heavy masonry piers, which had to be carried down to a considerable depth in order to secure a solid foundation.

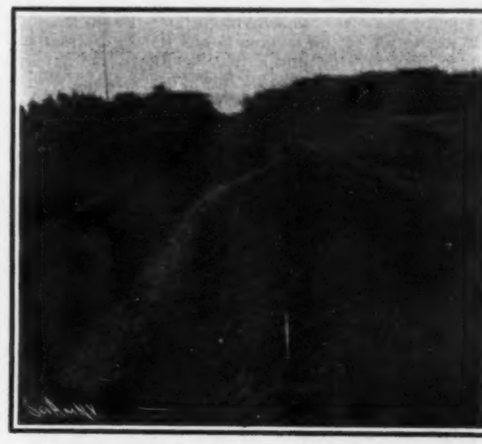
After leaving Benguella the route is sharp northwesterly; here greatest engineering difficulties were encountered. The climb from the seashore to the highlands of the "Divide," a rise of 5,000 feet, is somewhat sudden, the first stage of the plateau being gained at Monte Sahoa. From the traffic point of view this section will prove the heaviest, with many sharp curves and grades of 1 in 40, which are unavoidable owing to the contour of the country. The rise continues all the way until Bihé, some 220 miles distant from Lobito Bay, is gained. At one point the configuration of the ground is very steep, winding through a gorge and rising some 700 feet in two miles. It was found that at this point the gradient that would result and which could not be obviated would prove far too heavy for ordinary railroad operation. To overcome the difficulty two alternatives were propounded—the boring of a tunnel, or the making of a detour of some 60 miles in order to avoid the defile entirely. Both schemes, however, were rejected as impracticable, owing to the heavy expenditure that would be incurred and the length of time that would be necessary to achieve either result, and which would delay the forward progress of the line toward Katanga. Tunneling especially would have been a laborious undertaking, inasmuch as the stone to be excavated is of granitic structure with a remarkably close grain and hard texture. At this juncture Mr. Norton Griffiths, who was supervising operations, suggested the construction of a rack railroad upon this section, similar to that adopted for climbing certain of the Swiss mountains. As this scheme offered no insuperable objections, and was both the quickest and cheapest solution of the problem, it was accepted. The Lengue gorge through which this section, some two miles in length, extends is a meandering narrow defile, the bed of which is torn and strewn with large bowlders disintegrated by the flood waters, which rush down during the torrential rainy season. The sides are steep, and the railroad winds its way along the face of the cliff on one side, the average gradient being 1 in 16. The building of this stretch has proved the most laborious and difficult which has yet been completed, and according to the surveys that have been made will probably not be equaled in character throughout the remaining 800 miles. The rock proved so hard that it could only be removed by heavy blasting. Work was carried out without cessation night and day, in order to complete the rack section with all possible speed. At the mouth of the gorge a portable electric generating plant was installed, and across the defile at the point of working cables were stretched, from which were suspended large arc lamps to enable the work to be carried out during the night. After the rock was drilled and the dynamite cartridges tamped home, the electric lamps were hauled along the overhead cables beyond the zone of the explosion, while the gangs of native laborers withdrew to a safe distance. The charges were then fired and huge masses of rock loosened. While the drilling contingent resumed boring the native laborers pressed forward and cleared the debris of the previous explosion, that which was not required for ballasting and masonry work being discharged over the face of the cliff. By this means it was possible to gain the summit of the cliff in the space of a few months.



COMBINED RACK AND ADHESION LOCOMOTIVE FOR THE TWO-MILE RACK SECTION OF THE BENGUELLA RAILWAY.

At three points, owing to the contour of the gorge, three large viaducts had to be erected, and it is at the first of these near the entrance to the gorge that the rack section commences. Owing to the broken nature of the bed of the gulch, the masonry piers and abutments had to be of heavy design in order to withstand the force of the mountain torrents and the large bowlders brought down by the rushing waters. The first viaduct is about 295 feet in length, built up in five 59-foot steel spans of the open lattice girder deck type; the second structure is a single arched span, similar in design to that over the Zambesi River at the Victoria Falls, 137 feet 9 inches in length and weighing 124 tons; while the third viaduct is similar to that near the entrance to the gorge, and measures 236 feet in length and is made up of four 59-foot spans.

SAND-BALLASTED STRAIGHT SECTION ON THE COMPLETED LOBITO BAY-BENGUELLA SECTION.

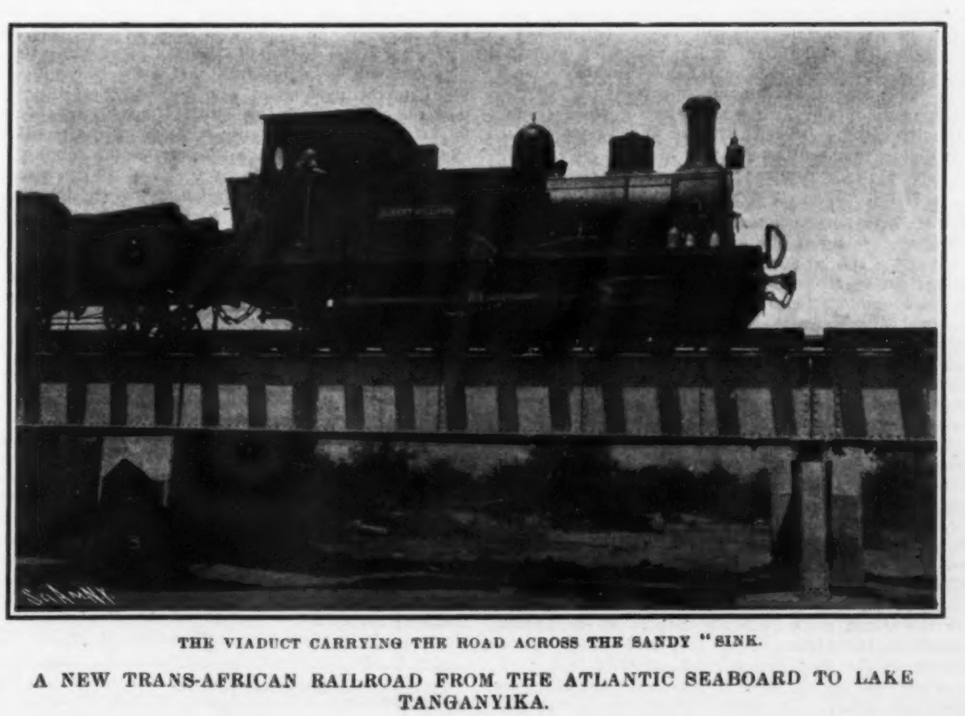


THE MADE-UP EARTHWORK READY FOR BALLASTING AND PLATE LAYING.

For railroading over this rack section a four-cylinder combined rack and adhesion type of locomotive has been secured from the Maschinenfabrik Esslingen, of Stuttgart, Wurtemberg. These engines are constructed on the Riggenbach system, are 6-coupled and provided with two trailing wheels under the firebox. For the rack section, with its gradient of 1 in 16, it has been designed to haul a train of 160 tons gross weight at a speed of 4.97 miles per hour, and over the lesser gradients of 1 in 40 at speeds ranging from 11.18 to 12.4 miles per hour. The maximum axle load permitted was 12 tons, and the rigid wheel base was restricted to 9 feet, 10.1 inches. The coupled wheels have a diameter of 3 feet 4 inches, while the trailing wheels are 2 feet 5.06 inches diameter. The pitch diameter of the rack driving wheel is 3 feet 1.6 inch. The tubes have a heating surface of 944.5 square feet, and the firebox 99.6 square feet, giving a total heating surface of 1,044.1 square feet, while the grate area is 20 square feet. The working pressure is 206 pounds per square inch. The tank capacity is 672 gallons of water, and the coal bunkers one ton. The total weight of the engine in working order is 45.34 tons.

The four cylinders, each having a bore of 17.13 inches and a stroke of 18.9 inches, are placed two on each side of the engine outside the frame and so disposed that the lower pair drive direct on to the central pair of the 6-coupled wheels. On the ordinary track the locomotive is run as a simple engine, using the lower pair of cylinders only, while on the rack the engine is converted from simple to compound working. The steam after being used in the lower cylinders is passed into the upper pair, which are thus low-pressure cylinders, and these latter by means of shaft and gearing drive the toothed wheel which engages with the rack rail laid between the adhesion rails. For starting under load on the rack, steam is admitted into the upper pair of cylinders through a special valve, by which arrangement the locomotive can be temporarily worked as a simple engine with high-pressure steam in all four cylinders, reverting to the compound working when the inertia has been overcome. For braking purposes, in addition to the general system of braking on all coupled wheels either by the vacuum or hand brake, there is a band brake acting on a drum on the driving shaft of the rack gear actuated by a screw and handle, and furthermore a brake system in which the shoes act on a grooved drum on the front coupled axle, this drum being solid with a toothed wheel 33.86 inches in diameter, engaging with the rack. It will thus be seen that ample braking facilities are provided.

From the top of the gorge the topography continues practically level through Bihé to Katanga, some 800 miles distant. The country, while rugged and covered with dense scrub, offers no serious hindrance to rapid construction. As the waterways flow north and south of this plateau, heavy engineering work in point of



THE VIADUCT CARRYING THE ROAD ACROSS THE SANDY "SINK.

A NEW TRANS-AFRICAN RAILROAD FROM THE ATLANTIC SEABOARD TO LAKE TANGANYIKA.

bridges or viaducts will be obviated, the gulches torn by mountain torrents that do exist being capable of bridging in small spans. Here and there mountain peaks project above the prevailing level, but they can be easily avoided without recourse to sharp curves or heavy gradients. The country remains at a level of 5,000 feet above the sea throughout the remaining distance to Katanga, affording magnificent panoramas over the surrounding country, while the climate and atmosphere are clear and invigorating. From Monte Sahoa at the top of the Lengue gorge, it was originally intended to carry the line a little southerly, so as to connect the important trading town of Gaconda with the coast, but this project has since been abandoned in favor of a more direct route *via* Bihé, the center of the Portuguese rubber industry. As the country thence to Katanga is practically level, involving little earthwork preparation, it will be possible to carry out constructional work at a high speed. Native labor under white supervision is being employed, and in this connection the supply is ample. The earthwork is carried out by the natives under Portuguese officials, supervised by the contractors' English engineers. Plate laying and the finer grades of work are carried out by skilled laborers of various nationalities who have flocked to the district.

The greatest difficulty that has been encountered has been in regard to water, for personal, machinery, and building purposes. Borings have been made at various points with Keystone drillers, but several trials have proved either abortive or yield such a small supply as to be practically useless. Consequently, at some places the sources of supply are unavoidably wide apart. The water that is generally found at a depth of 10 feet is too brackish and impure for aught but building requirements. In connection with the locomotives this scarcity has proved a serious handicap, though matters are now being remedied by the erection of cast-steel tanks of 5,000 gallons capacity, fed from bore holes sunk 70 feet or more near by, and capable of yielding some 1,000 gallons per day. So acute is this question of water supply, that in one place a distance of over 30 miles separates the two stations at which the locomotives can replenish their tanks.

A period of three years has been allowed for the completion of the railroad to Katanga, a total distance of 950 miles from the coast, but it is anticipated that the work will be completed in a much shorter period, in view of the previous experience gained in railroad construction in Africa, where the configuration of the country is favorable to rapid progress. When finished, not only will it result in the rapid opening of the mining region around Katanga and Lake Tanganyika, but at the same time it will play an important part in the development of the Transvaal, since a shorter and more direct route between Europe and Pretoria will be available, representing a saving of some 3,000 miles.

THE CASTELIN AUTOMOBILE PLOW.

By the Paris Correspondent of SCIENTIFIC AMERICAN.

THE new system of plowing by the use of a gasoline motor and a special automobile which has been lately brought out by M. André Castelin, of Paris, is attracting considerable attention in France. The system as operated at present is not an experiment, but has proved its value before agricultural commissions, who were impressed with its good performance. Briefly stated, the apparatus consists of a gasoline motor operating a drum, and is carried in a very solid iron framework, upon wheels so as to make it portable. When on the spot it is anchored by a special device. The plow, which can be of any form, is drawn along by the cable, and at the farther end the cable passes over a horizontal sheave which is fixed to a special support driven in the ground. With a reversible plow, the return strand of the cable can be used to bring the plow back and so cut the succeeding furrow.

The use of a gasoline motor for operating a cable system of plowing presents some decided advantages over the steam engine. A steam-operated cable-drum requires a large amount of fuel and water to be brought to the spot and a good estimate is 6 to 8 pounds of coal and 40 to 60 gallons of water per horse-power per hour. The same figures for a gasoline motor are but 0.9 pound of fuel and 0.15 gallon of water. For an 8-horse-power cable-drum we must transport per ten-hour day from the farm to the field, in the case of steam, 620 pounds of combustible and 3,000 pounds of water, or some 3,600 pounds in all, while for a gasoline motor we have but 70 and 90 pounds respectively, making 160 pounds in all. The economy is appreciated where, as often happens, the distance to the railroads is considerable.

The main body is formed of a very strong frame made of I-beams and well braced across. The tractive force which the motor will give is about 1,500 pounds with a motor of only 10 horse-power, and this is amply sufficient for working any kind of ground. With a heavier motor the tractive effort is, of course, much higher. To give an idea of the work done by the Castelin system, we may cite an experiment in working newly-cleared ground in the neighborhood of Paris, using a double Bajac plow upon the cable. With a 310-foot length of furrow (14 by 14-inch section) the time required to draw the furrow was only three minutes. The machine is shifted for the next furrow in half a minute. Here a pull of 1,100 pounds is used on the cable. According to M. Ringlemann, director of the testing station and professor at the National Agronomic Institute, the resistance of cultivated ground varies between 700 and 1,500 pounds per square foot and never exceeds 2,000 pounds for new ground. In the preceding tests the 10-horse-power machine gave a force of 3,410 pounds at a speed of 20 inches per second and 5,680 pounds when running at 12 inches per second, which comes near the usual working speeds, so that we have a great excess of power, allowing any kind of ground to be worked.

Another point which is to be brought out is the relative cost of the heavy steam tractor plows which are now in use and the new gasoline system, and the difference is striking. With a steam plow used in a recent test, two machines were employed and the cost of the apparatus figured from $12,000 to $16,000. It plowed twelve acres per day, working at 5 inches depth of furrow. The Castelin system is able to plow six acres per day with apparatus which costs only $1,600, giving five times as much work for an equal cost, not counting the question of fuel transport, which we have already mentioned. Still more striking are the data which Prof. Ringelmann gives for the cost of plowing an acre of land on the two systems of steam and gasoline cable drums. Estimating that horse labor costs $1.30 per acre, the steam apparatus will cost $80, and the petrol system only $14. Such a great difference in economy will be appreciated at once. These figures relate to the plowing of new ground. For cultivated land the cost is much less, and M. Castelin figures that by using the labor we already have on the farm, the expense is reduced to the interest on the capital and the cost of gasoline and goes as low as $3 per acre.

We may add that the motor has a special pulley mounted on the outside of the car frame, so that it can be used for driving threshing machines, cutters, pumps, and do all kinds of work on the farm. It can also be used as a hauling wagon, and when driving a fire pump it would prove of great service in the rural districts, especially in the villages.

THE CASTELIN AUTOMOBILE PLOW TRACTOR AT WORK.

INDIRECT METHODS IN ASTRONOMY.*

THE subject of indirect methods in science is a very interesting one. Thus we can measure very minute quantities of radiant heat by the electric current produced in a thermopile, or by the variation of an electric current due to the variation of the resistance of platinum. Very small movements may be measured optically, by changes in interference rings: the attraction of gravity at the earth's surface is measured with great accuracy, by counting the number of vibrations which a pendulum makes in a given time; the earth's magnetic force is measured in an analogous manner; the velocity of particles of radiant matter, or electrons, is measured by their deflection by the magnet; the average depth of the ocean is measured by the velocity of the tidal wave; and so forth.

Sometimes several indirect methods may be applied, and then the concordance of results is a proof of the accuracy of each. Thus the diameters of molecules of matter have been measured by the colors of soap bubbles, by the electrical action between zinc and copper, by surface tension, by movements of camphor on water, by theoretical conclusions based on the kinetic theory of gases. The quantities measured are very minute: thus 50,000,000 hydrogen molecules placed in a row would extend only one inch; forty thousand million million million of these would weigh one grain. Yet the results by different methods are remarkably accordant, considering the minuteness of the quantities measured.

In astronomy, angular distances are measured either by graduated circles, by eye-piece micrometers, or by measurement on a photograph; one co-ordinate of an angular distance may be measured by the time of passage over a fixed thread in the telescope. Motions in the line of sight are measured with the spectroscope; radiant heat by the thermopile or the bolometer. These are all direct methods. Distances may be measured by a triangulation, which may be considered a direct method, but this is in general not sufficiently accurate, and indirect methods give the best results.

The measurement of the size of a celestial body depends upon the determination of the distance. The mass must be determined indirectly.

To find the distance of a body in terms of our terrestrial miles, we must first find the diameter and figure of the earth, which is our base for triangulation. This is done by means of geodetic surveys, that is, by triangulation from carefully measured base lines, and extending far enough to determine the length of a number of degrees of latitude or longitude. By combination of the results obtained in different parts of the earth, its form and dimensions are determined.

From this, by observation of the parallax of the moon, or its displacement as viewed from different points of the earth at known distances apart, the distance to the moon can be determined with accuracy. The distance of the sun cannot be determined accurately by this method, on account of the small value of the parallax, less than 9 seconds of arc, and the difficulty of precise observation of the sun.

By Kepler's third law, the proportion of the distances of the different planets from the sun is known from their periodic times. If then one of these distances is known, all the others can be immediately found. Also the distance of any planet to the earth at any time, is in a known ratio to the distance of the sun. Hence a determination either of the absolute parallax of any planet, or of the ratio of its parallax to that of the sun, gives the parallax of the latter, and thence the dimensions of all the orbits.

The differential parallax may be observed when a planet transits the sun disk. This observation was the purpose of the expeditions which were sent to observe the transits of Venus in 1761, 1769, 1874, and 1882. The absolute parallax of a planet such as Mars or one of the asteroids, is determined by measuring its angular distance from neighboring stars.

A second method depends upon planetary or lunar theory. By mathematical deduction from the law of gravitation a formula is obtained which gives the elements of the planet's orbit in terms of the time. It is shown that certain terms of these formulæ for the orbits of Venus and Mars represent large secular variations, which have a well determined relation to the solar parallax. These secular variations being observed, the solar parallax can be calculated. Similarly the lunar theory affords means by which the sun's parallax can be determined from that of the moon.

A third method depends upon the fact that the motion of the earth in its orbit, combined with the motion of the light coming from a star, produces aberration of light, by which the apparent place of a star is thrown forward of its true place in the direction in which the earth is moving. This displacement is in different directions, according to the direction in which the earth is moving at the time, and can be determined accurately in angle by observations at different seasons of the year. The trigonometrical tangent of the angle is the ratio of the earth's velocity to that of light. If the velocity of light is found, that of the earth, and consequently the dimensions of its orbit, follow. The velocity of light is found by terrestrial observations.

Thus there are three general methods, the parallactic, that by gravitation theory, and the physical method. These are independent of one another, for the first method, that by observation of parallax, depends for its validity on Kepler's third law, which is a statement of results of observation, while the second depends on the assumption of the universality of gravitation. The third is entirely independent of the other two. The close accordance which exists in the results by the three methods is a strong proof of the correctness of the astronomical theories involved.

The linear diameter of a planet follows from its distance, when the angular diameter has been observed.

To determine the mass of the sun or a planet requires a previous knowledge of the mass of the earth. The earth's mean density is found from the deflection of the plumb-line by the attraction of a mountain, or by measurement of gravity at points above or below the surface of the earth, as compared with its value at the surface, or by comparing the attraction of the earth upon a body with that exerted on the body by a large metallic ball, as in Cavendish's experiment.

Knowing thus the mean density, and also the vol-

* Abstracted from the Inaugural Address of W. F. King as President of the Ottawa Section of the Royal Astronomical Society of Canada.

ume of the earth from its dimensions found in the manner above shown, its mass follows.

It is shown by gravitational theory that the constant ratio expressed in Kepler's third law of the cube of the mean distance to the square of the periodic time is, in different systems, proportional to the mass of the central body. Therefore the distance and time of revolution of our moon enables us to find, from the mass of the earth, that of the sun or of any planet which has satellites.

The mass of a planet without satellites is found by consideration of the perturbations which it produces in orbits of other bodies. The masses of satellites are determined in a similar way.

RADIOTELEGRAPHY BY CONTINUOUS ELECTRICAL OSCILLATIONS.

RECENTLY Mr. Valdemar Poulsen, of Copenhagen, gave a splendid demonstration of his new system of radiotelegraphy in London, of which Engineering publishes the following report:

Wireless telegraphy, Mr. Poulsen said in introducing his discourse, made use of the waves generated by a sparking oscillator. These waves were strongly damped; they began with great amplitude, somewhat like the explosive sound waves produced by a pistol shot, and died out rapidly. Undamped waves continued for a longer period with uniform amplitude; but it was only in 1900 that Duddell—in a remarkable discourse, delivered before the Institution of Electrical Engineers—had shown how to produce such continuous electric waves suitable for radiotelegraphy with the aid of his singing arcs. The problem had, indeed, not been far from being solved by Duddell. (Duddell's arrangement is indicated in Fig. 1.) When an alternating circuit containing capacity and self-induction was coupled in parallel with an electric arc fed by direct currents, the arc became musical under certain conditions, and an alternating current was produced in the alternating circuit, having the same rate of vibration as the note of the arc. Duddell had in this way obtained frequencies of 30,000 and 40,000, very high for electrical engineers, but far too low still for radiotelegraphy. Three and a half years ago Mr. Poulsen had commenced to study the question of how the frequency could be raised, and he had found that arcs burning in atmospheres of hydrogen or coal-gas and some other gases gave frequencies of about 1,000,000, which would yield us the wave-length of about 300 meters suitable for wireless telegraphy. He had first made the arc burn in alcohol vapor merely by placing a spirit lamp directly under the horizontal arc. The superiority of hydrogen might be due to its thermal and electrical properties, its high atomic velocity, and its great cooling power. (Mr. Poulsen did not dwell on this point.) As the velocity of sound in gases is by Newton's law, which later researches have only modified, proportional to the square root of the quotient : elasticity over density, we should expect more rapid vibrations in hydrogen, and that gas would propagate sound about four times as quickly as air. Mr. Poulsen, however, spoke mainly of the cooling effect of hydrogen, and the fact that it is advisable to cool the arc electrodes supports this argument. The anode could, he said, be made of a copper tube (Fig. 2) through which water circulated; the arc would then spring from an exchangeable ring at the end of the tube. The cathode was carbon. When both electrodes consisted of carbon (Fig. 3), the cathode might grow by deposition of carbon on it, and in order to insure a clean, sharp edge, the cathode was very slowly rotated at a circumferential speed of 0.1 millimeter per second; the anode was cut off obliquely as in Fig. 3, so that the arc always played between the upper edges. The arc was produced in a box made of marble; all the dimensions of the boxes shown were considerably less than 1 foot. Stout solid carbons were used.

A mixture of hydrogen and coal-gas, Mr. Poulsen continued, answered still better than hydrogen. Carbureted hydrogen or coal gas was constantly fed into the box; the smell noticed on Tuesday rather suggested the formation of acroleïn. Nitrogen also gave higher frequencies than air; ammonia was also effective, but objectionable (prussic acid is formed). Oxygen seemed to be the obnoxious element, probably because it gave rise to combustion of the carbon. The arc had to be adjusted to a certain "active" length, which increased with the current intensity and decreased with higher frequency; self-induction and capacity could be varied considerably. The usual active length of the arc was only 3 millimeters. In order to produce a greater potential gradient in the arc and to steady it, the arc was placed in a magnetic field, whose coils, branching from the main circuit, served also as choking coils. Fig. 4 explains the arrangement, and, further, the peculiar cross-connection, adopted with the object of doubling the potential gradient. A single arc on a 450-volt circuit had produced 160,000 oscillations per second and an oscillating energy of 1,200 watts. The same arc oscillating at 240,000 vibrations would yield oscillation energy at 900 watts. The proportion of continuous-current energy which was converted into oscillation energy was diminished when the frequency was raised, as the figures just given would indicate. Higher current intensity would increase the energy of oscillation only up to a certain maximum intensity. If more energy were required, several arcs could be connected in series; this had been done in the laboratory, but in practice one arc had so far sufficed, even in sending messages from Copenhagen to North Shields.

Successful demonstrations of resonance were interposed at this stage. A small circuit, comprising an arc in illuminating gas, was radiating. About a yard from it was a coil, say, 15 inches high, 6 inches in diameter (larger coils were also used) consisting of very fine copper wire, tuned to 700,000 oscillations per second. When the generator was tuned to the same period, a vacuum tube in the secondary circuit began to glow; but the approach of Mr. Poulsen's hand, or a slight alteration of the variable condenser, sufficed to disturb the glow. From a larger coil beautiful ramified discharges spurted out; when a metal rod was brought near, this ramification changed into a quiet flame. Then a fine copper wire was twisted about the core of the coil, so as to leave a wire tail pointing upward. As soon as the system was excited, the fine wire was seen to whirl round, describing a luminous cone. A Tesla transformer with 3,000 turns gave a very beautiful flame discharge.

Passing to a description of the station outfit, Mr. Poulsen showed their favorite transmitting arrangement, which is illustrated in Fig. 5. The antenna and its counter capacity might be made to act as the oscillation circuit comprising the arc, in which case the oscillations would be created in the antenna itself. Or the energy might be supplied to the antenna from a primary generating circuit by means of a coupling which might be close to loose, as in spark telegraphy. If the coupling were neither absolutely loose nor absolutely close, the frequency of the system would not be sufficiently defined, since the arc might develop one or two not very dissimilar periodicities. In the arc-wave system perfect tuning could be realized with both loose and close coupling, while in spark telegraphy a loose coupling was essential. In Fig. 5 the coupling was close—that is to say, the inductance is directly joined to the antenna, and also to the generating circuit, at a point near a loop. Signaling could be effected by various methods. To vary the length of the wave, apparently the simplest method, was not advisable, because the transmitting apparatus of each station would have to be characterized by two wave-lengths, and the number of stations which could operate simultaneously over the same territory, without mutual interference, would be reduced by one-half. According to another method, the telegraph key connected and disconnected the antenna and its counter capacity to and from the rest of the system; to protect the generator, a compensating oscillating circuit of weak radiation was introduced every time the key broke the antenna circuit, or the key could throw in resistance in the generator or antenna circuit. This last method was very simple and spared the contacts best. Other ways of inserting damping could also be resorted to, varying the length of the arc, the magnetic field, the gas feed, etc.

For the receiver perfect resonance and, therefore, loose couplings were indispensable. But as the waves were continuous, the detector need only form an intermittent part of the oscillating circuit. There would be no damping by the permanent inclusion of the detector then. The Pedersen "ticker" receiver (Fig. 6) operated as follows: The oscillation circuit was permitted to get well into action, undisturbed by damping; then the detector would suddenly be inserted and absorb the accumulated energy; the detector, consisting of an electrolytic cell, a thermo couple, or a bolometer connected to a telephone, would then give a musical note. The oscillation circuit of Fig. 6 contained a condenser which was intermittently shunted by a condenser of larger capacity placed in parallel to the telephone. The intermittent contact-maker, or "ticker," was a small electro-magnetic vibrator like a Neef hammer; the contacts consisted of two hooks of gold wire, fixed at right angles to one another. German silver, or silver and steel, would make the telephone sound louder, but they were not so reliable as gold and platinum. This intermittent operation of the receiver, which embraces some feature of multiplex telegraphy, seems to us—if we understood rightly—to be one of the most important advantages of the system. In spark telegraphy, the energy is stored up in the transmitter until a powerful spark discharge takes place; here the receiver energy is stored up. The capacity of the receiver system, the lecturer continued, was determined both by the condenser proper and the comparatively small and slowly varying capacity of the intermittent contact; this proportion of the capacities was a technical advantage, as it would allow of slight variations in the transmitted wave without any failure of the receiver being risked. As Morse signals consisted of dashes and dots, it was obviously to the purpose to introduce a "ticker" if a telephone receiver was to be used, as they did. The bolometer or thermo-couple, which would only momentarily enter into the oscillation circuit, might itself be in a tertiary circuit; apparatus of this kind, comprising a Pedersen ticker designed particularly for combination with a coherer, were explained by diagrams.

Coming to results, the lecturer pointed out that a spark-telegraphy station could, with very little alteration, be transformed into a Poulsen station. The sharpness of tuning with which stations could be worked without mutual interference was in practice about 1 per cent—e.g., stations A and B might work with waves of 600 meters, and C and D work over the same territory with waves of 606 meters. It should be mentioned that similar claims are made for spark-telegraphy apparatus. They had received with the aid of three receivers, all coupled to the same antenna, simultaneously three different telegrams, the three wave-lengths differing by about 4 per cent. As the generator gave out a spectrum of waves with wave-lengths ranging from 300 to 3,000 meters, several hundred stations might be worked over the same territory. The greater wave lengths carrying greater energy should be utilized for the larger distances, and the higher antennæ should be reserved for them.

Their first transmitting station had been erected at Lyngby, near Copenhagen,* in June, 1905. Their first receiving station had been nine miles from Lyngby. Another station was then built in the port of Esbjerg, 180 miles from Lyngby across the Danish Isles and Jutland, on the west coast of Jutland. With a consumption of energy of 800 watts, a radiated energy of 100 watts, a potential difference of a few thousand volts between the antenna and the earth, and wave-lengths of 700 or 1,000 meters, good telephone signals had been obtained at Esbjerg; by strengthening the magnetic field of the arc, the radiating power had been raised to 400 watts.

When on one occasion they had fitted up this station at Esbjerg to receive spark-telegrams, the receiver had given out an inextricable jumble of English and German signals from ships and shore stations, further complicated by the interposition of atmospheric discharges. When they tuned up for Lyngby again, com-

Fig. 1.

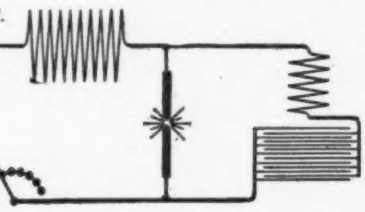


Fig. 2.

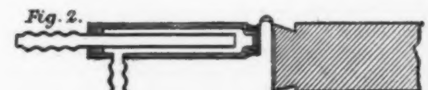


Fig. 3.

Fig. 4.

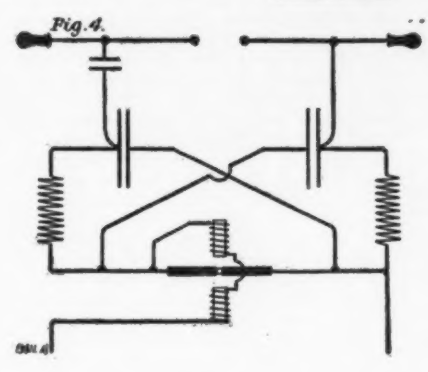


Fig. 5.

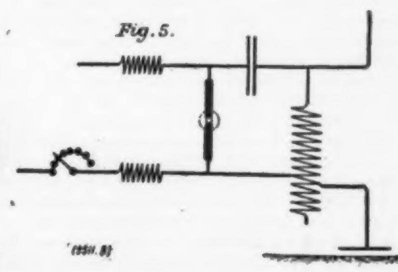
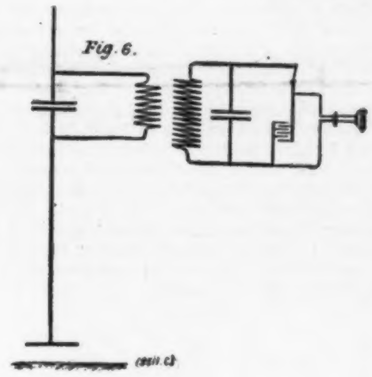


Fig. 6.



* There are three Lyngbys in Denmark; the one referred to is not the largest.

munication with Lyngby had at once been restored without the slightest disturbance from extraneous sources. Three masts had been erected at Lyngby, of which two were used as a rule. The wire fan was suspended from a rope connecting the two masts. With a power of one kilowatt, and a mass 100 feet in height, they had recently established perfect communication between Copenhagen and North Shields, a distance of 530 miles, 150 miles of which was overland. That result strengthened Mr. Poulsen's belief that 10 kilowatts should suffice to send radiotelegrams across the Atlantic. Concluding, the author summed up the chief advantages of the system: Extreme accuracy of tuning, rendering multiplex telegraphy available to an almost unlimited extent; non-interference with other lines; increased freedom from atmospheric disturbance; greater efficiency and economy, because the losses by leakage and by brush discharges would be smaller with the lower potentials. There were also great possibilities for wireless telephony.

THE ELECTRO-CHEMICAL AND ELECTRO-METALLURGICAL INDUSTRIES IN 1906.

By JOHN B. C. KERSHAW.

THE most striking progress in the year 1906 in connection with industrial electro-chemistry and electro-metallurgy has been made in the copper, iron, steel, and nitrogen industries. In other directions development is proceeding only slowly or has been entirely checked.

No new discoveries of industrial significance have been made, or new industries founded during the year. Details of the position in the various industries are given under the respective headings in the following:

ALKALIES AND BLEACH.

The past year has been one of fair prosperity in the electrolytic alkali and bleach industry, the great activity in trade having increased the demand for these staple chemicals and caused a slight improvement in prices as compared with the year 1905.

The Castner-Kellner Alkali Company, with works at Weston Point, reported a profit of £35,946 for the six months ending September 30, and distributed a dividend of 7 per cent on the ordinary shares; while the Electrolytic Alkali Company, which operates the Hargreaves process at Middlewich, in Cheshire, reported a net profit of £12,095 for the twelve months ending August 31, 1906, and were enabled to pay off some of the arrears of dividend that had accumulated on the preference shares. The Castner-Kellner Company have also erected a works at Wallsend-on-Tyne for the manufacture of sodium and certain of its derivatives. This works, which is utilizing power generated by the Newcastle Electric Supply Company, was placed in operation during 1906.

In Germany and America the industry appears to be in a satisfactory condition, but in Italy, France, and Switzerland it has experienced a severe check, owing to the over-production of bleaching powder and to the keen competition from the old Le Blanc manufacturers in the sale of this product.

The number of works engaged in the industry is now thirty-six, and the estimated production is 110,000 tons of 70 per cent caustic soda and 231,000 tons of 35 per cent bleaching powder per annum.

ALUMINIUM.

The year 1906 in the aluminium industry has been marked by the expiration of the Hall patents granted in 1889, relating to the electrolysis of alumina dissolved in fluorides, in America, and by a sudden increase in the demand for the metal in Europe. This increased demand had commenced to make itself felt toward the end of 1905. The reports of the British Aluminium Company and of the Neuhausen Company for that year, disclosing gross profits of £93,000 and £186,000 respectively, show that the industry has now entered upon an extremely prosperous stage of its history.

Although the European patents relating to the manufacture of aluminium by electrolysis have lapsed, the industry still remains somewhat of a monopoly in the hands of the original companies, for these have obtained control of all the more important deposits of bauxite, the mineral from which the pure alumina used in the electrolytic baths is obtained.

Large extensions of water power are now being carried out by the British Aluminium Company, on Loch Leven, and by the Neuhausen Aluminium Company, on the River Navigence, in Switzerland. When these are completed the producing capacity of these two companies will be doubled.

A new works has also been erected in the valley of Pescera, in Northern Italy, in connection with large water power developments in that locality, and this works is expected to come into operation during the present year.

The number of works engaged in the manufacture during 1906 has been eleven; the aggregate horse-power available in these has been 84,500, and the production for the year is estimated by the writer to be 12,000 tons, as compared with 8,500 tons in 1904 and 1905. No new uses for the metal have been found during 1906, but its applications in the motor-car industry and in metallurgy as a reducing agent are increasing rapidly, and account together for a large portion of the increased demand.

CALCIUM CARBIDE AND ACETYLENE.

The calcium carbide industry in the United Kingdom is represented by one small works at Askeaton, County Limerick, in Ireland. The greater portion of the carbide used for acetylene generation is imported from Norway, France, and Italy. Abroad the manufacture of carbide is slowly extending; the period of shrinkage which followed the boom of 1898-1900 has given place to one of expansion, several new works having been erected and put into operation during 1906. In France the industry is stated to be fairly prosperous, a state largely due to the strong control of the syndicate which manages the output and sales. In order to find another outlet for their product, this syndicate has founded recently a subsidiary company—La Société Française des Produits Azotes—with a capital of 1,000,000 francs. This company is to carry on the manufacture of calcium cyanamide by the Frank and Caro process, the new works being erected at Notre Dame de Briançon.

The utilization of calcium carbide for acetylene generation continues to make progress. Now that the futility of competing with electricity or gas in cities or urban districts is recognized, and the limits of the field of application for the new lighting agent are fixed, the acetylene industry may be considered to be established upon a sound basis. The total consumption of carbide in Europe approaches 100,000 tons annually, and this total is likely to increase, especially if the new manufacture of calcium cyanamide proves remunerative.

The latest form in which calcium carbide is being sold for acetylene generation is in sticks and blocks, molded from a paste made of powdered carbide and a binding material. These are being placed upon the market by the Acetyvone Manufacturing Company, of U. S. A.

CHLORATES AND PERCHLORATES.

Chlorates of potash and soda and the corresponding perchlorates are made at seven works, utilizing between 30,000 horse-power and 40,000 horse-power, the largest of these being that of Corbin & Cie., at Chedde, in the Hte. Savoie. The industry has been practically in a stationary position for some years, and 1906 has not served to alter the position, although the prices obtained for the potash and soda salts have slightly improved during the year, and now stand at 3½d. and 3¾d. per pound, respectively. The yield and efficiency of the electrolytic chlorate process have been improved by adding small amounts of resin and of hydrochloric acid to the liquid in the vats, this addition being covered by Corbin's French patent No. 339,251 of 1903.

COPPER.

The copper-refining industry continues to be the most successful and expansive of the electrolytic industries. The output of electrolytic copper for 1906 will probably reach the enormous total of 400,000 tons. In Europe the industry is stationary or actually declining owing to the difficulty of obtaining adequate supplies of raw copper or matte suited for the electrolytic process of refining. In America the refineries continue to grow in size, and it has been recently stated on reliable authority that the eight most important refineries of the States at the end of 1905 had an aggregate production capacity of 348,000 tons per annum, while many of these were undergoing further enlargement.

When one compares with this the output of 250 tons per annum of the first refinery erected by Elkington Bros. at Pembrey, in South Wales, the growth of the electrolytic refining industry is seen to be striking. The use of machinery for casting the anodes and for charging and discharging the refining vats is now general in these large American refineries. At the new Tacoma refinery, U. S. A., the anodes are cast from a rotary furnace holding 350 tons of metal, and the vats are charged and discharged by a 20-ton overhead traveling crane. The daily production of refined copper here is between 30 and 43 tons, equivalent to 12,000 tons per annum. Another new refinery is being erected by the Mountain Copper Company near San Francisco.

The Tacoma refinery is employing a copper-lead sulphide ore as raw material; but as a rule the American refineries operate upon purer ore, and use as anodes a metal containing 98 to 99 per cent copper, with 300 ounces silver and 40 ounces gold per ton. The slimes from the vats contain about 40 per cent silver and 2 per cent gold, with copper, lead, selenium, tellurium, arsenic, and antimony as impurities. The number of refineries now operating is thirty-four, eleven of these being located in America and the remainder in various parts of Europe and the Far East.

HYPOCHLORITES.

The only new development of interest during 1906 in connection with the production of hypochlorites by electrolysis, is the installation by the Borough Council of a plant working on the Hermite system in Poplar for the manufacture of a disinfecting solution. The paper read recently by Mr. Biggs upon this plant before the Faraday Society, and the discussion upon it, were reported in The Electrician of November 23, 1906, and it is unnecessary to devote further space to the subject in this review. The fact may be recorded, however, that the city authorities of Philadelphia have had a similar plant at work for some years, and that the experience obtained in its operation has caused them to dismantle it during the past year. Time will show whether the Poplar plant will prove more successful from a pecuniary standpoint.

FERRO-ALLOY.

The production of ferro-chrome, ferro-silicon, and other alloys of iron with the metals manganese, tungsten, molybdenum, and vanadium by electric furnace methods or by the "thermite" process, has developed in recent years into a very important branch of electro-metallurgical industry.

The chief development of this industry has occurred in France, where many of the works erected for carbide production are devoting their power to the manufacture of ferro-silicon and ferro-chrome, the two alloys in greatest demand. As regards the utilization of these alloys, the combinations of iron with chromium, manganese, tungsten, molybdenum, and vanadium are employed for introducing these various metals into steel, it being found that a more homogeneous ingot is obtained when the foreign metal is introduced in the steel in the form of a ferro-alloy.

Ferro-silicon is used for adding to cast iron just before pouring, a gain of 15 per cent in strength accompanied by a somewhat larger gain in ductility and softness being found in cast-iron test bars manufactured in this way. An addition of only 0.25 per cent Si to the iron in the form of ferro-silicon produces marked effects upon the mechanical properties of the iron. From 1 pound to 4 pounds of an alloy containing 50 per cent of silicon are added to 200 pounds of the molten metal.

NICKEL.

Electrolytic nickel is being produced by the Hoepfner process at Papenburg in Germany, and by the Orford Copper Company in America, while a Canadian company is about to erect a nickel refining works at Sault Ste. Marie. The Orford Copper Company has only recently taken up the production of electrolytic nickel, and is reported to be using a "secret" process, with nickel chloride solution as electrolyte. The cathodes are formed of thin sheets of nickel coated with graphite, measuring 3 feet by 4 feet, and the nickel is electro-deposited upon them until they measure ¼ inch in thickness. The average purity of the product is 99.5 per cent, and it is quite free from carbon; for which reason it is greatly in demand by manufacturers of German silver.

NITROGEN COMPOUNDS.

The year 1906 has been one of great activity in connection with the industrial development of processes for extracting nitrogen from the air, and a large number of works for operating either the Birkeland & Eyde or the Frank & Caro process have been planned, some of which are now in course of erection. The former method is based upon the use of the high temperature of the electric arc for causing combination between the oxygen and nitrogen of the air, the gaseous mixture of nitrous and nitric oxide being afterward absorbed in milk of lime to form calcium nitrate. The Frank & Caro method is based upon the absorption of nitrogen by calcium carbide at a high temperature, a product known as "Kalkstickstoff," or calcium cyanamide, being formed.

The Birkeland & Eyde process was worked out at Notodden, in Norway, where a small works, utilising 700 horse-power, was started in May, 1905. This has recently been enlarged, and 2,100 horse-power has been devoted to the manufacture here since July, 1906. A company has been formed in Christiania to exploit the new process in Europe and to take over and enlarge the existing works at Notodden. Developments are now in hand which will increase the power available at this place to 30,000 horse-power, and the annual production of calcium nitrate to 20,000 tons. In Germany the Badische Anilin und Soda Fabrik, of Ludwigshafen, are arranging to develop water power in the Bavarian Alps for operation of this process, while in France, Switzerland, and Italy other schemes of a similar kind are being pushed forward to completion.

The Frank & Caro process for the fixation of atmospheric nitrogen is being exploited in Switzerland, France, and Italy, an Italian company, the Societa di Produtti Azotati, of Rome, having acquired the patents relating to this process. A works utilizing 3,000 horse-power is being erected at Piano del Orte, and if successful it is intended to increase the capacity of this plant to 10,000 horse-power. The erection of a calcium cyanamide works at Notre Dame de Briançon, in France, has already been referred to under the heading of "Calcium Carbide." In Switzerland the Société Suisse des Produits Azotes, with head offices in Geneva, has been floated to carry on the same manufacture. It may be remarked that these new methods of obtaining the nitrogen of the air, in a form in which it will be available for agriculture and for other purposes in the arts and industries, are certain to come into wide use when the South American sources of combined nitrogen are exhausted. But it remains to be proved whether they can be worked to yield a profit under the present conditions of the nitrate industry. The nitrate of soda deposits of Chili at present supply three-fourths of the nitrogen requirements of the world, while the coal-gas industry supplies the remainder. The tapping of a third source of supply therefore is likely to lead to a marked fall in the selling values of all forms of combined nitrogen.

SODIUM AND ITS DERIVATIVES.

The production of metallic sodium by electrolysis of the fused hydrate is a small but growing electrolytic industry. According to Ashcroft, 1,200 tons of sodium are produced annually in America alone by this method of manufacture, while the production in this country and in France and Germany is probably double this amount. Ashcroft is now erecting a works in Norway for production of the same metal by electrolysis of the fused chloride. In this country the manufacture is in the hands of the Castner Kellner Alkali Company, and it is their intention to make sodium and its derivatives the chief products at the new works recently completed at Wallsend-on-Tyne.

The sodium produced is used chiefly for the manufacture of sodium peroxide and sodium cyanide, and only a comparatively small amount finds its way into use in the metallic form. In America fused sodium peroxide is now sold under the trade name of "Oxone," and is being used for the generation of pure oxygen by the simple addition of water to the fused salt. Its use has been suggested for keeping the air of submarines fit for respiration during prolonged dives under water.

TIN.

There is nothing new to report during 1906 relating to the detinning industry, which still appears to be worked with success in Germany and America, though, so far, the attempts to introduce it into the United Kingdom have been a failure. Hitherto the electrolytic stripping process has only been applied successfully to tin-scrap and cuttings, but Goldschmidt, of Essen, is now attempting to apply it to the old tin cans and boxes found in all city refuse. Goldschmidt's U. S. A. Patent 804,530, of November, 1905, describes machinery for compressing and perforating these discused cans and boxes. The removal of the grease, solder, and enamel is also necessary before they can be utilized in the tin stripping vat, but this does not present any serious difficulties, and the question of using this kind of material in the vats is one largely of labor costs of collecting and preparation.

ZINC.

Electro-metallurgists have been striving for years to perfect an electro-thermal process by which zinc may be extracted from its ores. It is doubtful whether success has yet been attained, although several processes are now working upon a small scale of operations. In Norway the De Laval furnace is in operation, in Italy Ferraris is experimenting with a similar method of electro-thermal extraction, while in England the Swinburne-Ashcroft chlorination process is at work at Weston Point, near Runcorn.

There is nothing new to record in respect of the development of these processes during 1906, and the wasteful retort method of zinc extraction still supplies over 95 per cent of the world's consumption of the metal. As regards the electrolytic or wet methods of extraction, the Hoepfner process is, the writer believes, still in operation at Hruschau, in Austria, and at the Winnington works of Brunner, Mond & Co., in Cheshire, but in each case the output of electrolytic zinc is small, and the process is not being adopted by other firms.

There is nothing new to report concerning electrogalvanizing.—The Electrician.

THE IMPORTANCE AND MANUFACTURE OF MEAT EXTRACT.

THE development of the industrial manufacture of meat extract originated in the middle of the last century, and is mainly founded upon the research work of Justus von Liebig, who established the principal outlines upon which the technical production of meat extract is based in order to extract from meat the stimulating substances without introducing into it undesirable large quantities of fat, gelatine and glue. Formerly there were meat preparations on the market under various names, such as "Bouillon Tablets," etc.; these, however, contained a superfluous ballast of protein and glue, owing to their method of manufacture, by boiling meat with steam or under pressure, while they were deficient in the essential constituents of our modern meat extract, the so-called meat bases and salts.

The production of meat broths by means of boiling meat with water has been practised from time immemorial and the habitual diet of meat soups included in the regular food of almost all races, and relished by rich and poor alike, is certainly the best proof of their beneficial action upon the digestive organs. The nutritive value of these broths, however, has been considerably overrated formerly; for it was generally held that they represented one of the most nourishing foods. In reality, they can only be looked upon as a stimulant or condiment; for this purpose they cannot be valued too high and are certainly superior in their qualities to coffee and tea. The erroneous view of earlier times was that soups were a perfect substitute for meat, an opinion that is untenable to-day.

Meat extracts share only in a very small degree in the process of metabolism; their main value lies in their property to stimulate the nerves and aid digestion; they act very beneficially by relieving the feeling of exhaustion and hunger, although they do not satisfy the hunger proper. They are of the greatest value in cases of mental or physical exhaustion and overwork, especially if it is necessary to supply new passive energy and stimulate the fatigued organism to increased activity. It stimulates the appetite and aids digestion by means of a better blood circulation. Its specific action has always proven very beneficial in the case of wounded soldiers, and as such is very much valued, especially by the French army, which recommends meat extract mixed with wine as an excellent stimulant. One pound of meat extract is sufficient to supply a soup of good quality for 128 men.

Meat extract adds considerably to the savoriness of foods, owing to its condimental properties; especially so with people who are obliged to live on a simple diet, such as seamen and Arctic explorers, who are compelled to live on salt meat almost exclusively. The manufacture of salt meat extracts a considerable amount of valuable meat bases and salts, so that an addition of meat extract to salt meat corrects these defects and thus prevents the appearance of certain diseases, such as the much dreaded scurvy. However, like every other stimulant or condiment, the substances of meat extract are liable to become poisonous if consumed in large quantities; a fact which is certainly of considerable theoretical importance, but which would hardly occur in practice. We have repeatedly referred to this on previous pages of this magazine. The alkaloids of coffee and tea are known to be poisonous; the excessive drinker of strong liquors succumbs finally to alcohol poisoning and, in spite of this, the consumption of condiments and stimulants does not decrease because if taken in moderate quantities they act advantageously. Experiments made by Kemmerich and Bunge have demonstrated that the consumption of large quantities of meat extract may result in death, owing to its very large percentage of potassium salts and organic meat bases stimulating the heart action in the beginning and paralyzing the same afterward.

Justus von Liebig deserves the credit of having guided the manufacturer of meat extract into the right path by pointing out that only those cold water-soluble substances possess the above-mentioned stimulating and valuable properties whereas the water-insoluble constituents represent the real nourishing or blood-producing part. As, however, these latter nutrients are contained in sufficient quantities in the customary foods, Liebig looks upon these so-called extractive substances (meat bases and salts) as the proper, valuable constituents of meat extract, the production of which is very desirable for mankind from the enormous meat sources of our South American prairies.

These discoveries of Liebig are also instructive for the practical house-wife in the proper preparation of soups. If, for instance, the soup is to be made for the nourishment of a sick person or an invalid, the meat should be put into cold water and gradually brought to boiling in order to dissolve as many of the extractive substances as possible. If, however, she wants to prepare a piece of very nourishing meat for the dinner table, the raw meat should at once be immersed into boiling water. This causes the albumenoids on the surface of the meat to coagulate immediately and thereby prevents the solution of the extractive substances.

There is no question that it would be most expedient to make the meat of those countries which have abundant sources available for countries with a deficient supply of meat, as the whole meat contains, besides its stimulating and condimental substances, the true nutritive elements. This, however, is hardly possible from a practical standpoint and it must be considered an enormous progress that at least the former part of the meat is utilized for mankind and is not entirely destroyed as previously.

In Frey-Bentos (Uruguay) 150,000 to 200,000 cattle are killed annually for the manufacture of meat extract, while formerly only the hides were used for exportation. 30 to 32 kilogrammes of clean meat, free from bones and fat, render 1 kilogramme of meat extract. As one animal in South America possesses on the average 150 kilogrammes of meat, it is possible to produce 5 kilogrammes of meat extract from the same.

Early in the fifties of the last century in Munich Pettenkofer manufactured meat extract according to the directions of Liebig; of course, in very modest quantities. At this time Gibert came to Munich, studied the process of manufacture, and in 1862 began manufacturing operations according to this method on a large scale at Frey-Bentos. He procured the right from Liebig to mark his product with the latter's name. This is therefore the oldest meat extract factory which still exists under the same name. There is another plant in Montevideo, Uruguay, that operates according to the process of Kemmerich; a third one has been established at St. Elena, Argentine. Australia produces a considerable amount of meat extract from sheep's meat; however, this does not enjoy the popularity of the other on account of its peculiar taste. The manufacture of meat extract is thus practically confined to these few countries. The United States of America are at an advantage, as they may use the large quantities of meat as such and are not compelled to utilize it only partially as in the production of meat extract.

The technical methods for the manufacture of meat extract are generally kept secret. There is no doubt, however, that the process is conducted in approximately the following manner:

The meat is freed as much as possible from bones, fat and gristle, finely chopped and extracted with cold or only very lukewarm water. The extract is now heated to boiling whereby the coagulable albumenoids are precipitated; after filtration or skimming of the same, the extract is evaporated to a sirupy consistency in a vacuum. The extract produced in this manner answers the requirements of Liebig, that is, it is free from glue, fat and protein and contains mostly only the valuable meat bases, such as creatin, creatinin, sarkin, xanthin, carnin and others. It also possesses a certain amount of sarco-lactic acid and phospho-sarco-lactic acid as well as the mineral constituents of meat which are especially rich in potassium salts.—Dr. P. Martens in Pure Products.

Twenty tons of brake shoes per month are stated to be used up in the New York Subway. The brakes are applied, it is said, for nearly one-quarter of the total time of running upon the local train runs, and for about one-eighth of the total running time of the express, or limited, trains.

PRACTICAL DIRECTIONS FOR MAKING PAPIER MACHE BUTTONS.

THOUGH buttons made from papier maché masses are tolerably hard and solid, they are nevertheless not sufficiently strong, and are therefore treated by saturating in linseed oil or amber varnish with subsequent drying at a temperature of 125 deg. C. The buttons are first thoroughly dried and coated with hot diluted amber varnish, pure, and hardening and drying well. They are then dried in a specially constructed drying oven at a temperature of 100 deg. to 120 deg. C. and thoroughly baked, so that when dry they appear dark brown in color, hard, and as if roasted. The coating, or rather saturating, is best performed by putting a number of buttons into a sieve, dipping the latter into the varnish, or linseed oil varnish, so that all the buttons are uniformly saturated, shaking them well at the same time, and then removing the sieve. The fluid is then drained off and the buttons thrown into wire nets, which are immediately placed in the drying oven. The buttons may also be put into a wide vessel containing hot varnish, and thoroughly shaken till they are uniformly saturated. If the first coating of varnish soaks in strongly, a fresh coat of amber varnish is applied, and the objects treated in the drying oven till the surfaces are strong enough. As soon as the objects are hard and ringing, they are polished with pumice and shave grass; round articles, such as buttons, are turned down on the lathe like wood till they are smooth and even in every part. A scouring tub or polishing drum may be used with advantage; large quantities may be treated with these contrivances. After this treatment the objects are thinly coated with various colors, as may be desired, using cinnabar, lamp black, chrome yellow, umber, or a mixture of red and black, etc., in amber varnish, and permanent white ground in clear copal varnish for red, black, yellow, brown, and white colors respectively, and dried in an oven at a temperature of 70 deg. to 80 deg. C. When dry, the coating should be repeated two or three times till a sufficient polish is obtained. Every coat must be polished with pumice and shave grass, and the whole process repeated till the surface is perfectly smooth and even, with no hollows or protuberances. When applying sensitive colors such as cinnabar (vermilion), chrome yellow, and especially white, the heat must not be too great, otherwise the objects in the oven will lose their color; it must not, on the other hand, be too slight, or the coating will not be hard enough.

If the objects are to be of one color, they are again varnished with clear copal varnish, and are ready for sale when dry. If, on the other hand, they are to be ornamented in any way, this is done now.

To make a satisfactory mass, a sufficient quantity of paper is first macerated. The best paper for this purpose is tissue or unsized printing paper. The paper is torn into short strips, steeped in hot water, and then pounded till it is divided into little pieces. Gypsum is then put into the hot size, and well stirred, sufficient gypsum being used that the mixture may be tolerably thick; then the paper is added, and the whole again well stirred with a piece of wood. Finally, the mass is diluted by adding more size till it is thin enough to be easily worked into the required articles. The object of first making the mixture thick and afterward diluting it is to avoid the necessity of straining it, since lumps can be much more easily disintegrated in the thick mass. The most important point in the hardening is the thickness of the object; an invariably uniform composition is therefore not advisable. As a rule, not more than one part of paper pulp should be added to three parts of the gypsum paste prepared with size, but this quantity may vary according to the dimensions of the object. The following proportions give good results:

1. 30 parts of gypsum paste, 15 parts of paper pulp, well stirred and then diluted, produce a useful mass for very delicate and easily-drying articles; it has the same hardness as soft wood, and can be treated in the same way. When dry it is as heavy as water.
2. 30 parts gypsum paste, 12 parts paper pulp.
3. 30 parts gypsum paste, 10 parts paper, 5 parts of rather hard slate powder.
4. 30 parts gypsum paste, 8 parts paper, 8 parts slate powder. This mixture hardens somewhat more quickly.
5. 30 parts gypsum paste, 10 parts slate powder, 5 parts paper pulp.
6. 40 parts gypsum paste, 5 parts paper; this mass is adapted for thicker articles. It dries quickly, does not break easily, and is always as hard as wood. The size should be added in the proportion of 1 part to 8; if less is taken, the quantity of foreign substances added may be correspondingly increased. Chalk may also be substituted for the slate powder. The proportions of gypsum and paper specified above are parts by volume, not by weight.

The mass is poured into molds coated with linseed oil. Thin articles will be hard enough in five to fifteen minutes to be taken from the molds; thicker objects require a longer time (from one to two hours) as the size will not cool so rapidly. When the mass in the molds feels as elastic as India rubber to the touch, so that the object can be taken out, the size has hardened. The gypsum will not set until an hour or two later on account of the size. The paper also retards the setting of the gypsum; and as it moreover possesses the property of retaining the absorbed moisture for some time, thicker castings, if they contain too much paper, may remain for some days in a pliable, elastic condition till the gypsum finally sets.

The masses can also be colored as desired by adding coloring substances.

7. 50 parts by weight of finely-ground and washed clay slate are mixed in a suitable vessel with 20 per cent of rag paper and 30 per cent of burnt gypsum, with the addition of a sufficient quantity of water and stirred to a liquid paste, which is poured into closed hollow molds, the latter being previously coated with finely-ground slate, gypsum powder, or some fatty substance. After the mass has remained for a few minutes in the mold, a more or less solid crust will form; any of the still fluid mass which remains in excess is poured out of the mold, and the object may now be taken out. As soon as the moisture is removed from the object by drying, the latter is treated in the usual manner to give it the necessary hardness and strength, and finally coated as desired with paint, varnish, paraffin wax, India rubber, etc. The advantage of this method of manufacture is that the fluid mass mixed with gypsum can be poured into the closed molds, in which it rapidly hardens; consequently, the molds are ready for use again in a few minutes.—Neueste Erfindungen und Erfahrungen.

THE RECENT DERAILMENT AND WRECK ON THE NEW YORK CENTRAL RAILROAD.

THE probable causes leading to the recent disastrous wreck of an express passenger train on the New York Central tracks near Woodlawn were discussed in the issue of the SCIENTIFIC AMERICAN of March 2. It was shown in that article that the immediate cause of the wreck was the lateral displacement of a rail under the heavy thrust exerted by the two electric locomotives which were hauling the train. Subsequently to the publication of the article, considerable evidence has been given at the coroner's inquest, throwing light on the disaster, and the engineering department has made public some investigations of the effect of steam and electric locomotives when running over a curve of this character, which by the courtesy of the company we are enabled to publish herewith.

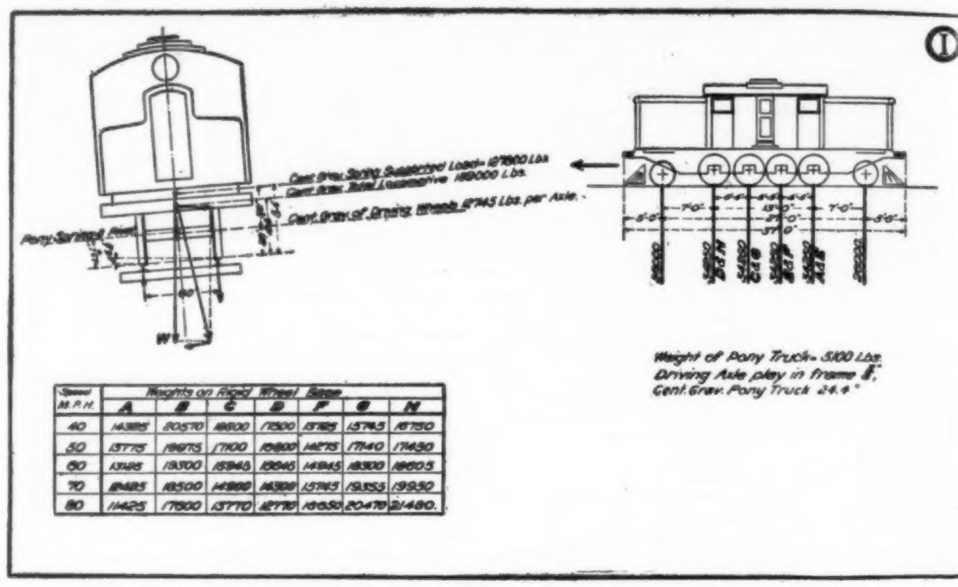
In the article in the SCIENTIFIC AMERICAN we gave it as our opinion that the super-elevation of the outside rail at the point of the accident was not sufficient for the speed at which trains were being run over the curve, and that it was altogether insufficient for the probably very high speed at which the electric train in question was being run at the time of the accident. From the accompanying plan of the curve, it will be seen that it is spiraled; that is to say, the 3-degree curve does not commence on the tangent, but the tracks are curved successively through increasing degrees of curvature, starting at 30 minutes and leading up gradually throughout the spirals to the full curvature of 3 degrees. The theoretical super-elevation of the outside rail on a 3-degree curve for the schedule speed at which the trains were run is over 6 inches.

At the time of the visit of a representative of this journal to the scene of the accident, it was noticed that apparently the super-elevation of the express tracks was no greater than that of the local tracks; and the question naturally suggested itself as to why a higher elevation had not been maintained on the high-speed tracks.

The super-elevation established by the inspector of tracks, or whoever it was who was immediately responsible, would seem to indicate that that man failed to appreciate the nature and action of a spiral curve, and crudely reasoned to himself that if $4\frac{1}{2}$ inches was sufficient at one point of the curve it was sufficient all through. Whether this be the explanation or not, the incident certainly serves to suggest that the time should be hastened when the heads and leading assistants in all those departments of a railroad which have to do, not merely with the construction, but with the physical operation of the road, should be men qualified by technical training to thoroughly appreciate the static and dynamic stresses to which all parts of the railroad are subjected under the heavy strain of daily operation.

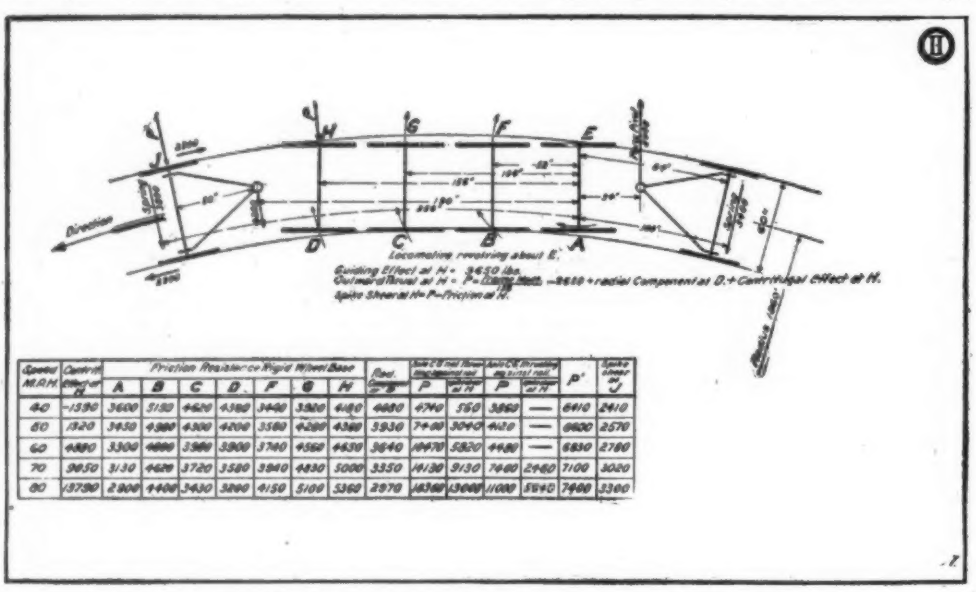
The need for technical qualification in every department, and not merely in the engineering department, is further emphasized by the fact that, in the wreck under consideration, a light train of five cars should have been sent out with two unusually powerful electric locomotives at the head of it. Probably, when the order was given, the thought of the possibilities of high speed and heavy concentrated stress on track, due to this "double-heading," never entered the mind of the official who was responsible for the order. Without knowing who gave this particular order or what were his technical qualifications, we venture the statement that no man with a technical training would have sent out a train of that make-up, without express warning to the motorman to handle his controller gently and take the curves well within the schedule speed.

In publishing the following statement by the company's engineers of the comparative effect of steam and electric locomotives on a 3-degree curve, we would remind our readers that these figures hold true of, and, indeed, are based upon, the condition of an absolutely perfect track, held in theoretically absolute level and curvature, and for a single locomotive running at exactly the speed, 60 miles an hour, assumed for the calculations. Any irregularity, such as flatness or fullness at any point of the curve; any variation, such as a soft spot tending to give more elasticity at one point than another in the curve; or any excess of the speed above that chosen for the calculations, would, of course, change the figures enormously; and it is to such variations from the physical condition of the track, from the speed, and from the theory as to the relative reaction of the rail against the various wheels of the locomotive, that we must look for an explanation of the disaster. Personally, we have as yet observed



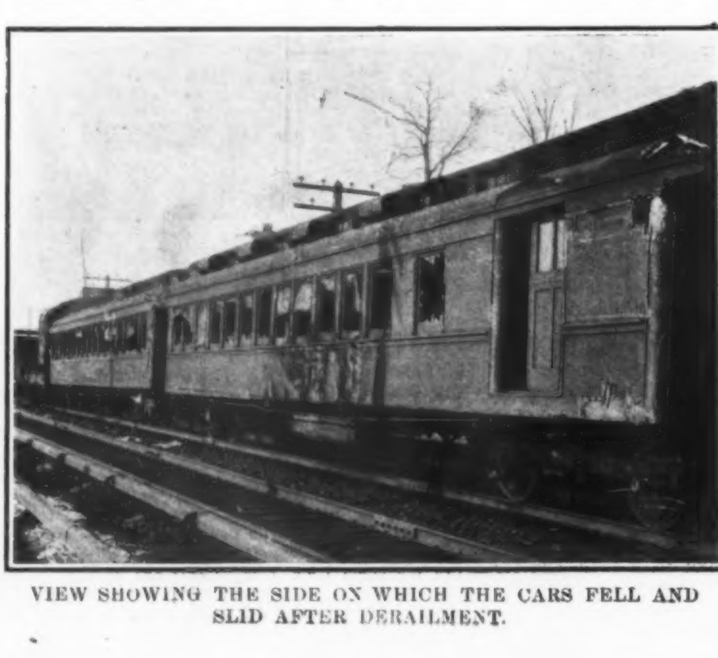
Speed M.P.H.	Weights on Rigid Wheel Base						
	A	B	C	D	F	G	H
40	14385	20570	18800	17500	15165	15745	16750
50	13775	19875	17100	15800	14875	17740	17490
60	13185	19300	15945	15645	14945	18300	18605
70	12485	18500	14980	14300	15785	19355	19930
80	11425	17800	13770	12770	16650	20470	21480.

END AND SIDE VIEWS OF N. Y. C. & H. R. RR. ELECTRIC LOCOMOTIVE.

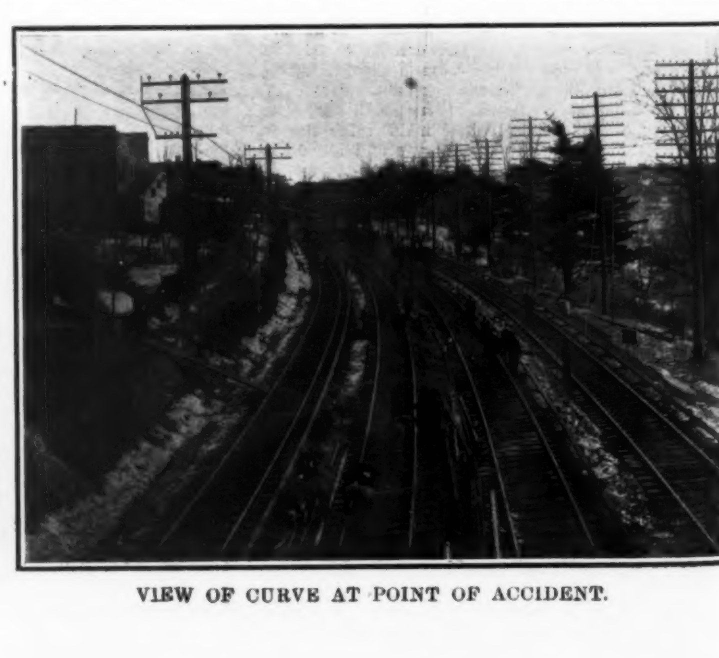


Speed M.P.H.	Centrif. Effect at H	Friction Resistance Rigid Wheel Base							Rad. Component at D	Axle C & rail flange bearing against rail		Axle C & threading on outer rail		P'	Spike shear at J
		A	B	C	D	F	G	H		P	at H	P	at H		
40	-1590	3600	5150	4620	4380	3440	3920	4180	4680	4740	560	3860	—	6410	2410
50	1320	3450	4380	4300	4200	3580	4280	4360	3930	7490	3040	4120	—	6600	2570
60	4880	3300	4800	3980	3900	3740	4560	4630	3640	10470	5820	4480	—	6830	2780
70	9050	3130	4620	3720	3580	3940	4830	5000	3350	14130	9130	7460	2460	7100	3020
80	13730	2900	4400	3430	3260	4150	5100	5360	2970	18360	13060	11000	5640	7400	3300

PLAN OF WHEEL BASE OF N. Y. C. & H. R. RR. ELECTRIC LOCOMOTIVE.

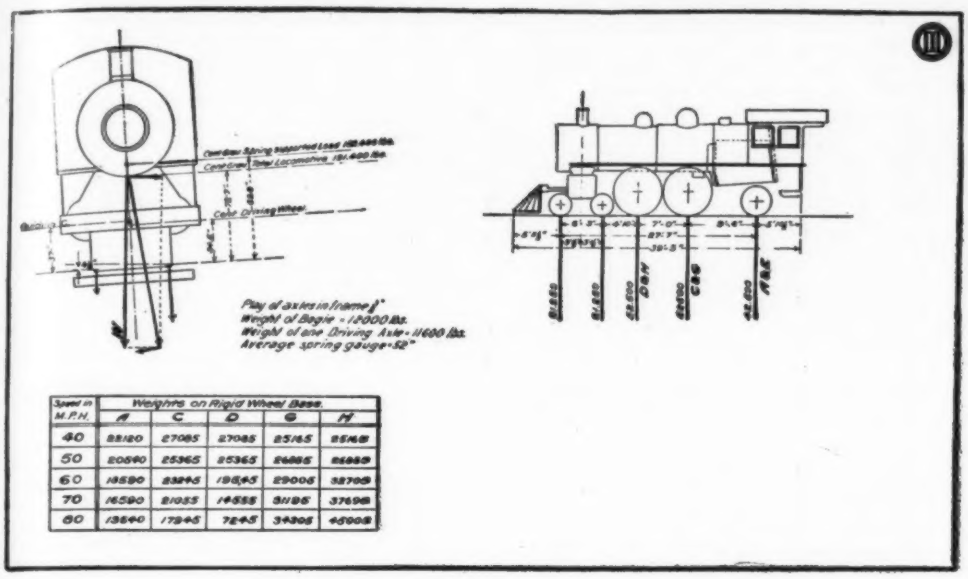


VIEW SHOWING THE SIDE ON WHICH THE CARS FELL AND SLID AFTER DERAILMENT.



VIEW OF CURVE AT POINT OF ACCIDENT.

and heard nothing to qualify our belief that the displacement of the rail was due to the impact of the leading driver of a train which was probably running at 70 miles an hour, against a rail which was slightly inside or outside the true line of curvature, and was below its proper elevation.



Speed in M.P.H.	Weights on Rigid Wheel Base.				
	A	C	D	G	H
40	28120	27085	27085	25165	25168
50	20590	25365	25365	26865	26889
60	18590	23245	19645	29005	32705
70	16590	21055	14555	31195	37698
80	13640	17945	7245	34305	45008

END AND SIDE VIEW OF ATLANTIC TYPE STEAM LOCOMOTIVE.

STATEMENT OF COMPARATIVE EFFECTS OF STEAM AND ELECTRIC LOCOMOTIVES ON A 3-DEGREE CURVE, SUPER-ELEVATION 4½ INCHES, SIMILAR TO THE WOODLAWN ROAD CURVE ON THE HARLEM DIVISION AT THE POINT OF ACCIDENT, FEBRUARY 16, 1907.

The statement has been published that "there is no science of curve mechanics." While this in a general way is a correct statement, it is nevertheless true that the subject has been quite fully discussed by Wellington in "Railway Locomotion" (pages 281 to 313) and the essential elements of the problem and methods of calculating indicated. Experimental determination of values for the various constants entering into the problem is a very difficult matter, and is the reason for the non-existence of a science of curve mechanics.

A partial analysis of the guiding effect provided on steam locomotives shows that the fundamental elements have been considered, and the guiding effect determined therefrom and borne out in practice.

The guiding effect provided for electric locomotives of the New York Central is not only theoretically in accord with what is required, but has the same structure and relation of parts as already provided on steam locomotives and operating sucessfully.

There might be mentioned three fundamentals of "mechanics of curve resistance":

(1) Component of slipping in the direction of the radius, due to curvature.

(2) Component of slipping in the direction of the tangent of track, due to unequal rail lengths inside and outside.

(3) Net effect of centrifugal force (super-elevation of outer rail considered).

The locomotive must be revolved against these forces Nos. 1 and 2 and such a pressure applied as will cause the locomotive to follow the curve. The point about which the locomotive revolves with respect to itself as affecting the wheel slippage may be determined mathematically for all practical purposes, and the stresses resulting from these two effects can be easily determined by calculation.

In determining the above, due consideration should be given to the action of the rigid wheel base on the curve in question, taking into account the clearance in the gage and the clearance between the main drivers and the rigid frame.

It will be appreciated that the radial slip on the front outside driver when rounding a curve is self-contained, and of itself does not tend to displace the rail, and that the radial slip on the inside front driver does tend to displace the outer rail acting through the front axle to the outer front driver.

If the clearance between the driving-wheel hubs and the locomotive frame is more than the ordinate of the curve at the second axle, the second axle will run to outer rail until the flange of outer second driver bears against the rail, and thus the frame of the locomotive does not have to carry the radial slippage of the second set of wheels.

The centrifugal effect (3) and super-elevation of the outer rail are radially calculated and need no explanation.

Thus with the major elements taken into consideration, it is entirely possible to practically calculate all of the guiding effect necessary.

To solve the problem to the last refinement becomes a complicated and tedious investigation.

The slight variation under actual conditions of operation, condition of track, stiffness of parts, etc., introduce constantly changing stresses, which would make a solution to the last refinement on any one given condition of no practical value.

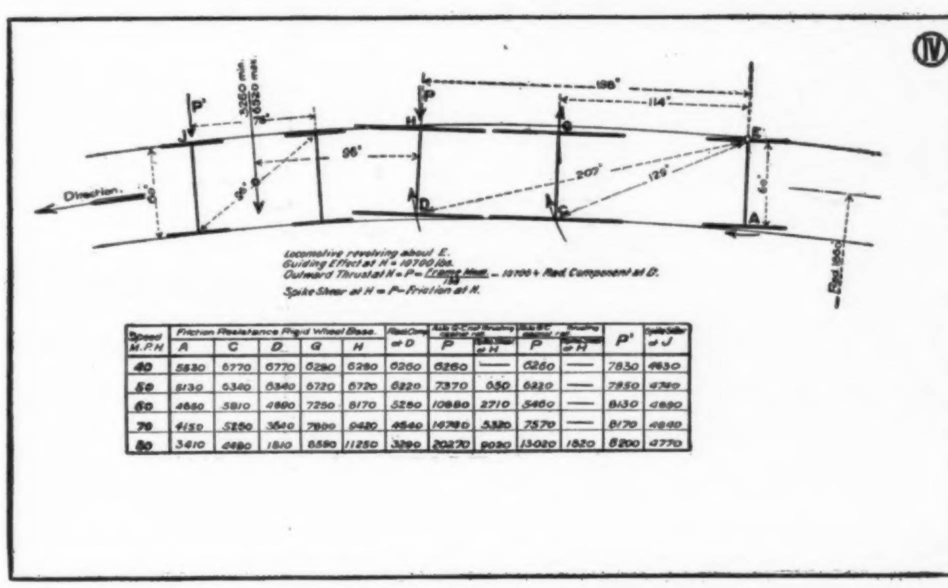
With due consideration to the fundamental and major elements, the problem can easily be solved and the guiding effect determined sufficiently for all practical purposes.

Considering (first) the condition where the second driving axle bears against the locomotive frame and so transmits the radial thrust of the second axle to the outer front driver, a comparison of the New York Central electric locomotive with the Atlantic type steam locomotive on a 3-degree curve with a 4½-inch super-elevation shows that the pressure of the steam locomotive driver against the rail is greater at all corresponding speeds. The resultant shear on the spikes, however, allowing for the friction of the rail on the tie plates, is less with the steam locomotive than with the electric up to about 80 miles per hour, where the shear on the spikes due to the outer front driver is practically the same for both.

The difference between the pressure against the rail and the shear on the spikes is affected so far as the drivers are concerned by the height of the center of gravity under the influence of centrifugal force increasing the vertical pressure on the outer rail. The greater effect of the higher center of gravity of the steam locomotive disappears, however, at the higher speeds by reason of the increasing preponderance of the horizontal force due to centrifugal action.

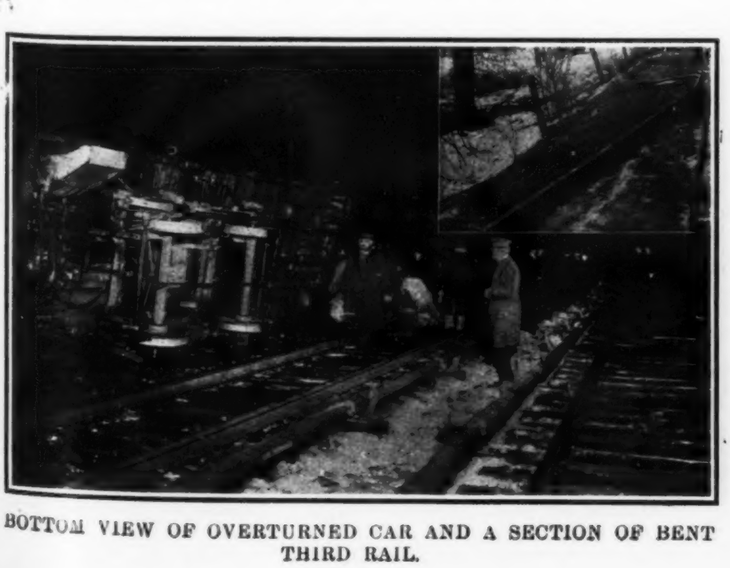
At about 90 miles per hour the shear on the spikes for the steam locomotive would not only be in excess of that of the electric locomotive, but at this speed the steam locomotive would be in danger of overturning.

The maximum shear on the spikes is not necessarily caused, however, by the driving wheels of the locomotives, but at certain speeds may exist at the leading wheel of the guiding truck. Although the pressure of the guiding truck wheel against the rail may be actually less than that of the driver, the weight upon the rail of the guiding wheel is so much less that the resultant shear on the spikes is consequently greater.

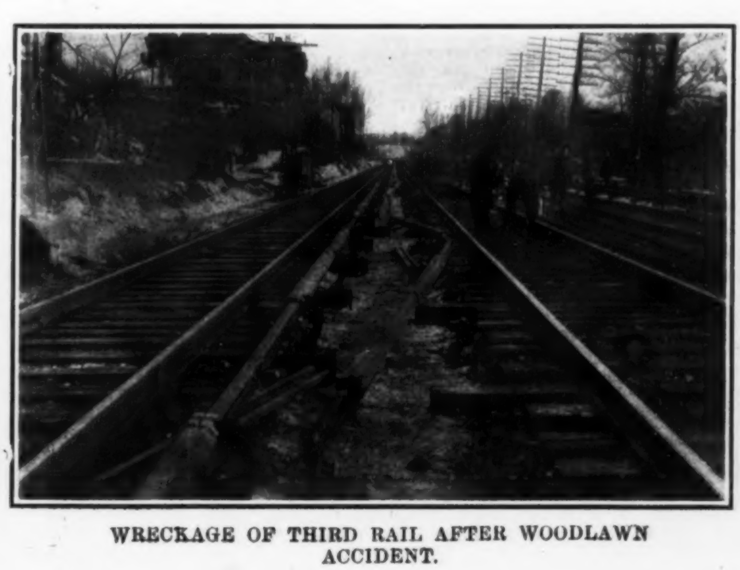


Speed M.P.H.	Friction Resistance Rigid Wheel Base.					Rad. Comp. at D	P	Spike Shear at H	P	Spike Shear at H	P'	Spike Shear at J
	A	C	D	G	H							
40	5830	6770	6770	6280	6280	6260	6260	—	6260	—	7830	4630
50	6130	6340	6340	6720	6720	6220	7370	650	6220	—	7950	4740
60	4660	5810	4890	7250	8170	5280	10880	2710	5460	—	8130	4690
70	4150	5250	3640	7800	9420	4540	14780	5320	7570	—	8170	4840
80	3410	4480	1810	8590	11250	3290	20270	9030	13020	1820	8200	4770

PLAN OF NEW YORK CENTRAL ATLANTIC TYPE STEAM LOCOMOTIVE WHEEL BASE.



BOTTOM VIEW OF OVERTURNED CAR AND A SECTION OF BENT THIRD RAIL.



WRECKAGE OF THIRD RAIL AFTER WOODLAWN ACCIDENT.

On the electric locomotive the shear on the spikes, due to the guiding truck, is in excess of that due to the drivers up to about 40 miles per hour.

On the steam locomotive the shear on the spikes due to the guiding truck is in excess of that due to the drivers up to about 65 miles per hour, and this shear exceeds that of either the driving or truck wheel of the electric locomotive up to this speed.

Considering (second) the condition where the second driving axle clears the locomotive frame by reason of the end play, and so bears directly against the outer rail without transmitting to the leading driver the thrust due to its radial slip.

The pressure against the rail of the leading steam locomotive driver as in the first condition is greater at all corresponding speeds. The resultant shear on the spikes is less, however, with the steam locomotive due to the effect of its higher center of gravity.

Under this (second) condition with the electric locomotive the shear on the spikes due to the guiding truck is in excess of that due to the drivers up to about 75 miles per hour.

On the steam locomotive the shear on the spikes due to the guiding truck is in excess of that due to the drivers at all speeds, and this shear exceeds that of either the driving or truck wheels of the electric locomotive up to 75 miles per hour.

Regarding the stress on the outer spikes of the outside rail, it will be seen from the attached tables that for a speed of say 60 miles per hour on a 3-degree curve with a super-elevation of 4½ inches, the maximum shear with the most unfavorable conditions is for the electric locomotive 4,440 pounds, as compared with 4,890 pounds for the steam locomotive.

The ultimate shearing resistance of the standard spikes used on the curve in question ranges from 14,440 pounds to 17,060 pounds. Assuming a factor of safety of 4, the permissible shear per spike is 3,810 pounds to 4,265 pounds.

The 100-pound rail in use on the curve acts as a continuous girder distributing the stresses over several spikes, but to be conservative two spikes may be taken as resisting the unbalanced outward thrust. Consequently, at 60 miles per hour we have actual maximum shears with either steam or electric locomotives ranging from 4,440 pounds to 4,890 pounds borne by two spikes, which with a factor of safety of 4, are proper for shears of 7,620 pounds to 8,530 pounds. In other words, the actual factor of safety is approximately 7.

In conclusion, it appears that the electric locomotive imposes equal or less unbalanced stresses than the steam locomotive on the 3-degree curves properly maintained, with super-elevation of 4½ inches, and that the shearing force on spikes, one on the outside of the outer rail in each tie, with tie plates, is far within the limits of safety for speeds in excess of the so-called "equilibrium speed" of about 46½ miles per hour to which the super-elevation of 4½ inches corresponds.

It is considered that never have such precautions been taken in the design, construction, and testing of new motive power as in the instance of the electric locomotives for use by the New York Central & Hudson River Railroad in the New York Electric Zone. Not only did the vice-president in charge of electrification associate with himself the best talent obtainable in the country, but also the contract for the construction of the locomotives was intrusted to one of the most reputable electric manufacturing companies in the United States, with the requirement that associated therewith should be one of the most reputable locomotive manufacturers, so as to secure a combination of the talent of both concerns.

Following the thorough discussion, investigation, and decision as to design, the actual construction of the locomotives was limited to one machine, so that after thorough test any needed improvements that were discovered might be incorporated in the remainder of the total order of thirty-five locomotives.

The first completed locomotive was tested on a six-mile experimental track for over two years, covering over fifty thousand miles of actual service, under the constant inspection of the vice-president in charge of electrification and his associates; also of both manufacturing companies and of inspectors appointed by the operating department that was to use the locomotives, as well as by the construction department.

As these electric locomotives were completed they were sent to the New York zone, and there given a second inspection and test under the actual conditions existing in the New York zone. It might be here added that the six-mile experimental track was purposely of a much inferior type of track construction to that existing in the New York zone, so that any tendency to undue effect by the electric locomotive on the track would be accentuated and the necessary modifications demonstrated more quickly than had the track been of the same superior quality that existed in the New York zone.

Correction is needed of a wrongful impression given by the public press that the testimony given regarding the shifting of the track in the ballast on one of the curves in the experimental track at Schenectady during high speeds was an indication of something wrong about the electric locomotive. Exactly the contrary deduction should be drawn. The electric locomotive was purposely driven at speeds of 75 miles per hour around a curve that was elevated for but 60 miles per hour, so as to accentuate any tendency that might exist with the locomotive to spread the gage. This very high speed caused a centrifugal force sufficient to move the ties in the gravel ballast, but there was absolutely no widening of the gage under such extreme conditions, thus demonstrating that even such excessive speeds around insufficiently elevated curves, producing a centrifugal force sufficiently great to shift the track in the ballast and distort the curvature, would still not cause a widening of the gage on this inferior track. In other words, this test demonstrated that the method of spiking curves in ordinary practice was sufficient to meet even abnormal conditions.

The result of the tests on the experimental track and also in the New York zone demonstrated from a practical standpoint the thorough acceptability of the electric locomotives to the satisfaction of all concerned, including the vice-president in charge of electrification, his associates, the representatives of the two manufacturing companies, and the inspector of the operating department.

So far as known, there have never been such exhaustive tests of new motive power before placing in actual service. In steam locomotive practice it is usual for new types of locomotive power to receive their first thorough tests in actual service in hauling trains, and any necessary modifications in design are then made as a result of such actual service on the road. It is well known that almost all of the modern types of steam locomotives have developed in actual service necessity for modifications. In the instance of these electric locomotives, however, the tests were made on experimental tracks or on regular tracks hauling dead trains, so as to purposely avoid any experimentation involving at the same time the hauling of trains loaded with passengers.

The above statement is made as showing the extra precautions and pains taken with these electric locomotives.

TABLE OF COMPARATIVE SHEAR ON SPIKES AT LEADING TRUCK WHEEL AND AT DRIVER WHEELS FOR ELECTRIC LOCOMOTIVES AND CENTRAL-ATLANTIC TYPE STEAM LOCOMOTIVES, ON THREE DEGREE CURVE, SUPER-ELEVATION 4½ INCHES.

Electric Locomotive.

	K	1	K—1	F	F¹	L	F—L	F¹—+L
Miles per Hour.	Rail Thrust Leading Truck Wheel.	Friction Between Rail and Tieplate Leading Truck Wheel.	Shear on Spikes by Leading Truck Wheel.	Rail Thrust Leading Driver.	Rail Thrust Leading Driver, Second Driver Against Rail.	Friction Between Rail and Tieplate Leading Driver.	Shear on Spikes by Leading Driver.	Shear on Spikes by Leading Driver, Second Driver Against Rail.
40	6410	4000	**2410**	5180	4380	4180	1000	200
50	6600	4030	2570	7020	4200	4360	**2660**	....
60	6830	4050	2780	9090	4050	4650	**4440**	....
70	7100	4080	3020	11550	6400	5000	**6550**	1400
80	7400	4100	3300	14420	10530	5300	**9060**	5170
Steam Locomotive (Atlantic).								
40	7830	3200	**4630**	6260	6260	6280	*....	...
50	7950	3210	**4740**	7370	6220	6720	650	....
60	8130	3240	**4890**	10880	5460	8170	2710	....
70	8170	3330	4840	14740	7570	9420	**5320**	...
80	8200	3430	4770	20270	13020	11250	**9020**	1820

Black figures represent maximum shear by either leading truck wheel or driver, under worst conditions.

TABLE SHOWING WHICH LOCOMOTIVE, STEAM (ATLANTIC) OR ELECTRIC, AND THE PART THEREOF, EXERTS THE GREATEST UNBALANCED PRESSURE ON THE OUTER RAIL OF A THREE-DEGREE CURVE 4½ INCHES SUPER-ELEVATION.

Twenty-five Per Cent Coefficient of Friction Between Wheels and Rails and Between Rail and Tie Plate.

Maximum Pressure of Truck of Driving Wheel of Electric or Steam (Atlantic). Second Drivers Not Bearing Against Outer Rail.

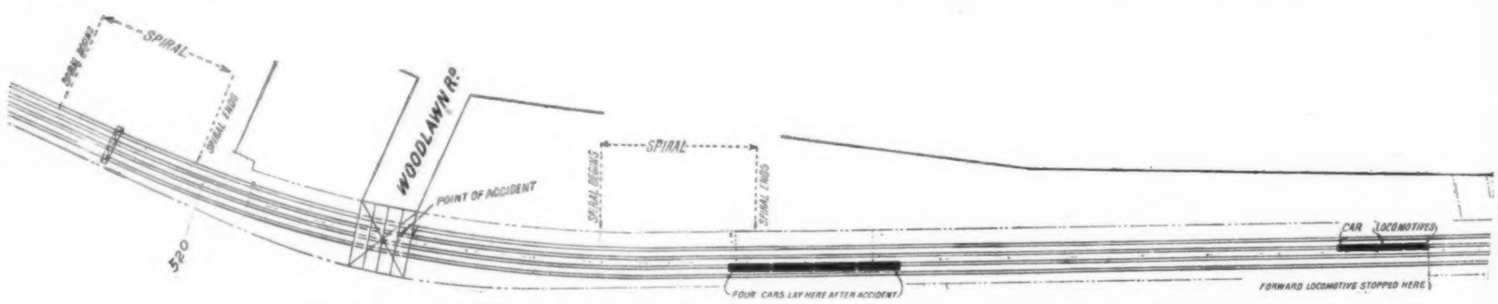
Miles per Hr.	Against Rail.		Resultant Against Spikes.	
40	Steam truck	7830	Steam truck	4630
50	Steam truck ...	7950	Steam truck ...	4740
60	Steam driver ..	10880	Steam truck	4890
70	Steam driver....	14740	Electric driver....	6550
80	Steam driver...	20270	Steam and electric driver	9000

On a three-degree curve with the clearance provided in the design, the outward thrust of the second driving axle would be carried by the flange of its outer wheel. Therefore the following values are based on—

Maximum Pressure of Truck or Driving Wheel of Electric or Steam (Atlantic) Second Drivers Bearing Against Outer Rail.

Miles per Hr.	Against Rail.		Resultant Against Spikes.	
40	Steam truck	7830	Steam truck......	4630
50	Steam truck ..	7950	Steam truck	4740
60	Steam truck ...	8130	Steam truck......	4890
70	Steam truck ...	8170	Steam truck......	4840
80	Steam driver ...	13020	Electric driver ..	5170

Therefore, except in two instances, the electric locomotive shows less maximum unbalanced pressure than the steam locomotive.



THE CURVE ON WHICH THE DERAILMENT OCCURRED, SHOWING DETAILS OF ACCIDENT.

SCHEDULE WEIGHTS OF STEEL AND IRON PLATES.

In purchasing iron or steel of any section by weight where the number of lineal feet or sizes are specified, it is frequently the case that sections and plates are rolled heavy. In order to make an allowance which shall be fair both to the mills and the purchaser, it is customary to allow a margin of 5 per cent over the calculated or theoretical weights; this weight is then termed schedule weight. The actual weight is paid for if under this margin; any excess is to the gain of the purchasing party.

In the case of wrought-iron plates this gives rise to a very simple formula, which is:

Weight in cwts. = area in square feet × thickness in inches × ¾.

Stated as a formula $W = \frac{3}{4} \times A' \times T''$.

For steel a further 2 per cent is added.

Example W. I. plate 10′ × 8′ × ⅞″.

$$\begin{array}{r} 10 \\ 8 \\ \hline 80 \\ \tfrac{7}{8} \\ \hline 70 \\ \tfrac{3}{4} \\ \hline 26.25 \\ .02 \\ \hline .5250 \\ 26.25 \\ \hline 26.78 \text{ cwt.} \end{array}$$

The formula is easy to remember and can be applied in other ways.—American Machinist.

The public problems of agriculture have been slow to gain recognition. The agricultural questions that we customarily discuss are those of the individual farmer. The burden of our teaching has been that the farmer must be a better farmer. Only in recent years has it come to be fully recognized that agricultural problems are of the greatest national and governmental significance. Consider how recent is the Land Grant Act, the secretaryship of agriculture in the President's cabinet, the experiment station act, the origin of a definite farmers' institute movement, the development at public expense of fertilizer and feed controls and other policing policies, the making of liberal grants of public money for specific agricultural uses.

GAS ENGINES AND MARINE PROPULSION.

FROM time to time, as advances are made in gas-engine practice, the question of the use of such engines for marine propulsion is raised. As one difficulty after another is removed by improvements or new systems, we reach a stage nearer the goal. It is evident that sure advances are being made in the right direction, but the difficulties still are many, and the steps somewhat small and slow, compared with the distance to be traversed. For instance, we take up a paper—plenty of them have been submitted to societies and institutions—and read about the application of gas engines to ships. We hear of schemes for sets of engines capable of developing 3,600, 5,000, or more horse-power, and all sounds well; but we also know that the largest amount of power yet installed in the form of gas engines on board ship is only a mere fraction of these amounts. For this discrepancy there must be good reason, especially as the names of many able men are connected with the study of this problem.

The chief difficulties encountered in this matter arise from the necessity for any system of marine propulsion being adaptable to a large variety of circumstances, and, if the expression may be used, elastic in nature.

In the matter of fuel, the system chosen must be suited to the supply obtainable in all parts of the world. In the matter of power it is necessary that there should be a wide range for working under all conditions of weather and circumstances; and in the matter of handling, the engines should be prompt and easy to reverse, and, in fact, perform all the duties at present carried out by steam. With regard to the first, it is futile to equip a vessel with a gas-producer plant using anthracite. The only fuel possible is bituminous coal, and that, too, in extremely variable qualities. But the producer must be prepared to use these different qualities with, at least, something approaching success. We are told that producers for bituminous coal have now been successfully designed, in which the various accessory appliances are either simplified or altogether abolished. Others have suggested the provision of coke-burning producers, the coke being made on board; this, however, usually being condemned as too cumbrous. It is by no means improbable that this producer difficulty, as well as others, will be surmounted. The subject is making rapid strides, and will no doubt develop to a degree which is at present difficult to gage.

Given a successful producer capable of using any grade of bituminous coal, there still remain such difficulties as reversing and reduction of power. This problem has been attacked in several ways, but with results as yet not wholly satisfactory. Indeed, the choice at present rather falls upon that which is the least crude, rather than that which is best. Reversing may be done by the propeller, but this only with small vessels; or it may be managed by rotating the cam shaft. Again, by adding considerably to the equipment it may be managed by electrical driving, or the result may be attained by the system suggested by Mr. J. T. Milton, M.Inst.C.E., in his recent paper before the Institution of Civil Engineers. Again, a suggestion has been put forth by Mr. A. Vennel Coster, in a paper before the Manchester Association of Engineers, that, with three sets of engines, in order to reduce power or bring a vessel to rest, one screw might be reversed while the other two still went ahead, and so on.

In the electrical drive, in which a gas engine drives a dynamo, connected up to a motor on the propeller shaft, the horse-power of the machinery to be paid for is three times that required to drive the vessel. In Mr. Milton's system of separate engine and compressor, with the example he gives of a 3,250 indicated horse-power engine, compressing gear requiring about 1,450 horse-power is necessary. Thus the machinery paid for amounts to 6,150 horse-power, while the net output of the installation is 3,250 horse-power. Of course, the propelling engine, being on the two-cycle system, would be relatively cheap. Machinery comprising eight or eleven cylinders, together with all moving parts, etc., does not impress one favorably. Mr. Milton's plan includes three expansion cylinders 25½ inches in diameter for the propelling engines. For the compressors two double-acting air cylinders 31 inches in diameter and two double-acting air cylinders 18 inches in diameter for the first and second stages of a two-stage compressor may be chosen, this being driven by a four-cylinder tandem gas engine, of cylinders 24½ inches in diameter. As an alternative, it is suggested to complete the second stage of the compression in one cylinder, 25 inches in diameter, instead of two of 18 inches, and to drive the compressor, a tandem two-cylinder engine, cylinders 34½ inches in diameter.

Mr. Vennel Coster's system appears to us no less unsatisfactory. His proposal certainly involves no large auxiliary plant of compressors and driving engines; but to keep engines going full speed ahead and to counteract their effect by running other engines full speed astern seems a most unmechanical method of surmounting these difficulties. It is probable that the efficient reduction of mean pressure may be attained by fairly satisfactory methods, this being possible by Mr. Milton's plan, and, it would appear, also by certain other means. The chief difficulty, of course, in this is in the fact that the poor mixtures are difficult to ignite. With tandem vertical cylinders 50 per cent reduction of power is possible by cutting out certain cylinders. Reduction of power below a certain point renders the engine liable to stop, no flywheels, or only very small ones, being possible in marine work.

A further difficulty which presents itself to the economical mind is the use to be made of gas from the producer when the engines are not required. On ceasing to draw gas for the purpose of running the engines, the temperature of the producers must be maintained by continuing the gas production. Something must be done with this. Mr. Coster uses it by running his engines at full speed, one counteracting the others. Mr. Milton makes no suggestion on this point, and we presume that that not required for driving his compressor plant would be allowed to run to waste.

Altogether, the problem is one full of knotty points. Although we are talking airily of installations of many thousands of horse-power, and are only building a few of a few hundred, and while the difficulties that suggest themselves at present appear, on present knowledge, difficult to surmount satisfactorily, we do not doubt that as progress is made, these will all disappear one after another. There is quite possibly a great future before this form of propulsion for marine purposes, but it would seem to be well to be not too ambitious till matters are a little more advanced. The two branches of the subject of producers and gas engines are, as yet, not far advanced even in land practice, and experiment in marine work might well seem more advisable in schemes of moderate size than on the lines recommended by many recent writers on the subject, whose great aim appears to be mainly to obtain (on paper) some combination of cylinders capable of giving so many horse-power.—Engineering.

THE LIMITS OF THERMAL EFFICIENCY IN INTERNAL COMBUSTION ENGINES.

AT a recent meeting of the Institution of Civil Engineers, the paper read was "On the Limits of Thermal Efficiency in Internal Combustion Engines," by Dugald Clerk, M.Inst.C.E. The following is an abstract of the paper:

The Institution Committee on the Standards of Efficiency of Internal-Combustion Engines, among their recommendations as to the standard engine of comparison for internal-combustion motors, recommended that for the purpose of the standard, air—assumed to be a perfect gas having a value of $\gamma = 1.4$—should be taken as the working fluid. For the ordinary four-stroke-cycle engine, the formula giving the efficiency then is,

$$\gamma = 1 - \left(\frac{1}{r}\right)^{0\cdot4}$$

where $\frac{1}{r}$ is the ratio of the minimum volume to maximum volume. The committee were satisfied that with good engines giving their best economy, the actual efficiency divided by the ideal efficiency determined by this standard could be expressed by a ratio which varied between 0.5 and 0.7. This was deduced from separate tests made by Prof. Meyer and Prof. Burstall. Prof. Burstall's tests also showed how inefficient design would decrease the ratio, as in some of his tests means involving greatly increased cooling surfaces were employed to increase the compression, and were found to considerably diminish the ratio. These tests showed further how too high flame-temperature also decreased the ratio. The committee required, however, further knowledge as to the effect of the dimensions of the engine on the ratio, and accordingly they made tests on three engines of 5 inches, 9 inches, and 14 inches diameter cylinders respectively, giving 6, 24, and 60 I. H. P. In these engines, taking the mechanical efficiency to be 88 per cent, and calculating the I. H. P. from B. H. P., they found that the efficiency ratios were 0.61, 0.65, and 0.69 in the three engines. The tests showed, therefore, that by bearing in mind the slight changes in the ratio due to difference in dimensions, a close approximation to the best indicated efficiency to be expected from a given compression could be obtained by the use of a factor varying between 0.60 and 0.70, according to the dimensions of the engine. The tests also showed very clearly the small increase in economy of large engines in comparison with small ones, there being only 12 per cent increase between 6 H. P. and 60 H. P. The possible efficiency with the actual fluid used in the engine was known to be less than that given by the air standard. The committee considered that a definitely known standard from which the actual efficiency could be deduced by using a multiplier found experimentally, allowing for the imperfections of the engine as well as for variations in the properties of the working fluid, should be adopted until the properties of the working fluid were accurately known. The author has examined the results of the test made by the committee, and has made some further experiments on the large engine used in the test, with a view to finding the true heat-distribution in the engine.

The balance-sheet given by the committee is as follows:

	L	R	X
Exhaust waste	35.3	40.0	39.5
Jacket waste	23.5	29.3	25.0
Radiation	7.6	10.0	7.3
B. H. P.	26.7	28.3	29.8
	93.1	107.6	101.6

In obtaining this balance-sheet the exhaust waste was determined by calorimeter, jacket waste measured, and the radiation includes friction of the working parts. The B. H. P. was determined by rope brake. In order to reason as regards properties of the working fluid, it is necessary to know the I. H. P., the loss of heat during explosion and expansion, and the heat in the gases at the end of expansion. These quantities are not given in the ordinary balance-sheet, as determined above. In the ordinary test the jacket loss is always over-estimated, because some heat which ought to go to the exhaust calorimeter flows to the water-jacket after the opening of the exhaust valve and all through the exhaust stroke of the engine. The piston friction also will appear in the water-jacket. The author has therefore attempted to adjust the balance-sheet from data given in the committee's report. Taking the mechanical efficiencies for the three engines, L, R, and X, as 0.84, 0.85, and 0.86, the friction percentage of total heat is 5.1, 5, and 4.9 respectively. Deducting this from the jacket waste, corrected values for heat to water-jacket, 21, 26.8, and 22.6 per cent are obtained. Using these values, and reducing to percentage, assuming that the error in total heat is not in the I. H. P. item, a new balance-sheet is obtained.

	L	R	X
Exhaust waste	41.1	37.1	39.9
Jacket waste } True radiation }	27.1	29.6	25.4
I. H. P.	31.8	33.3	34.7
	100.0	100.0	100.0

The ideal efficiencies in these engines are practically the same, and assuming that one-third of the heat going to the engine is converted to work, and that the heat loss occurs near the beginning of the stroke, the difference between the jacket plus radiation losses in any two engines should be three times the difference between the I. H. P.'s. In the L and X engines this is found to be exactly the case. The jacket waste in the L engine is evidently too low, and on the above considerations should be 34.1. This value of jacket waste for the L engine will give an exhaust waste of 34.1, which is practically the same as that determined by calorimeter. It appears, therefore, that in the L engine some heat which should have appeared in the water-jacket has been lost. This corrected balance-sheet is probably more accurate than that obtained in the test; but there is still some heat found in the water-jacket which should be in the exhaust. The experiments give no means of determining this amount. The balance-sheet, however, gives a method of calculating the maximum possible efficiency of the actual fluid. Adding exhaust waste to I. H. P., and dividing I. H. P. by the sum, possible efficiencies for the three engines of 0.482, 0.473, and 0.465 are obtained. In obtaining these efficiency values, however, it has been assumed that the heat is lost at the beginning of the stroke, and therefore the values are not accurate. If the distribution of heat loss were known, the true adiabatic could be constructed and correct results obtained.

To check the results, indicator diagrams which give the correct mean pressure have been studied. From the composition of the exhaust gases and the charge temperature, the weight of the charge is found to be 0.14 lb. From the diagram, the temperature drop from the end of expansion to charge temperature is 1,745 deg. F. The specific heat of the gases by weight, assumed constant, is 0.185. From these values, obtained from the numbers given in the committee's report, it appears that 43 per cent of all the heat of the combustible gases is accounted for in the exhaust. This gives a balance-sheet for the X engine.

	Per cent.
Exhaust waste	43.0
Jacket waste and radiation	22.3
I. H. P.	34.7

The exhaust waste here would obviously be greater if specific heat increases with temperature. From this balance-sheet, calculated as before, an efficiency of 0.447 is obtained; with air, the efficiency would be 0.49. These considerations show the difficulty in using the actual fluid as a standard. In spite of the great labor expended on the experiments, only a rough approximation to the true heat distribution can be arrived at.

In 1884 the author made experiments on cooling after explosion in a closed vessel. Many other investigators have since done similar work, but cooling of a cylinder having a moving piston had never been investigated. The author made further experiments, and determined the cooling in the X engine. The engine was run at normal speed, and when a charge had been drawn in, the rollers actuating the inlet and exhaust valves were slipped, so that the valves remained shut. The explosion then took place, and the gases instead of being discharged were alternately compressed and expanded. An indicator card gives a cooling curve, showing temperature fall during successive revolutions of the engine. From these cards the mean apparent specific heat of the gases in the cylinder has been deduced, the gases being practically the same composition as those in the committee trials. The values given increase with increase of temperature, and have been called apparent specific heat values, because certain facts discovered are inconsistent with the change being entirely specific heat change. Calculations assuming these numbers to be the true specific heats are, however, very nearly accurate. From the cooling curves and specific heat values so determined a balance sheet has been obtained for the X engine as follows:

	Per cent.
Heat flow during explosion and expansion	16.1
Heat contained in gases at end of expansion	49.3
Indicated work	34.6

Comparing this with that found by the committee, it is seen that the indicated work is the same in both. There is, however, less heat flow during expansion,

and more heat in the gases at exhaust. This shows that about 21 per cent of the heat in the gases at the end of expansion goes to the water-jacket during the opening of exhaust valve and exhaust stroke. This is considered a more accurate balance-sheet than has yet been obtained. Calculating the ideal efficiency as before, the value 41 per cent is obtained. From the values of specific heat given, the adiabatic may be calculated, from which the ideal efficiency is found to be 39.5 per cent, showing that the actual engine has converted 88 per cent of the heat which it possibly could convert into indicated work. The new method has been checked by a test of a small Stockport engine in the author's laboratory, which gave similar results to those given by the X engine.

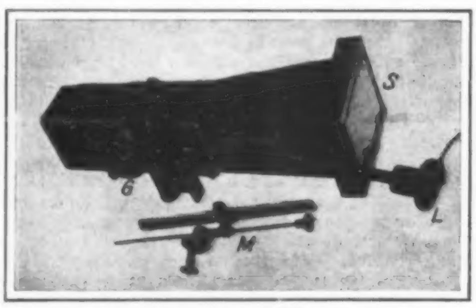
Tables have been calculated showing the ideal efficiencies for different compressions using the specific heat values given, and show that roughly the air standard is 20 per cent too high, and that if gamma be taken 1.285 for the explosion line, and 1.37 for the compression line, the change of specific heat between 1,700 deg. C. and 1,000 deg. C. commonly used in practice is too small to produce much error. More investigation is, however, required before even the apparent specific heat values can be accurately known for the various mixtures used in internal-combustion motors.

Much has been recently done, including experiments by Prof. Hopkinson, Messrs. Bairstow and Alexander, and Prof. Burstall; but until further knowledge is obtained, the air standard, as defined by the committee, gives the best basis for comparing the performances of different engines.

THE SCHULTZE MANOGRAPH FOR TAKING INDICATOR CARDS OF GASOLINE ENGINES.

By the PARIS CORRESPONDENT OF SCIENTIFIC AMERICAN.

THE Schultze manograph, or optical indicator, is an instrument designed to give an accurate diagram of the pressure obtained in the cylinder of an internal-combustion engine. By the use of a moving spot of light, the diagram showing the relation of the pressure within the cylinder to the angular position of the motor shaft is thrown upon a ground-glass screen, where it can easily be observed by the eye or photographed. The working of the apparatus is shown in the diagram. At 7 is a shaft connected by a suitable transmission with the crankshaft of the motor. On

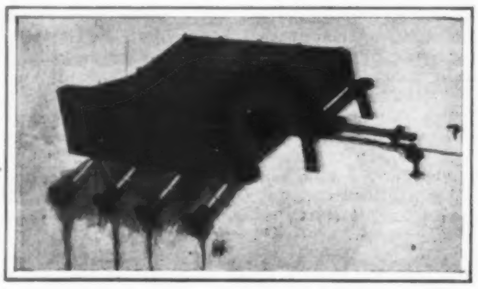


THE SCHULTZE MANOGRAPH AND ITS ATTACHMENTS.

the top of this shaft is mounted an eccentric, which works within the flat metal plate, 5, and causes it to oscillate a pivot fixed at 4. The flat plate carries a mirror, 6, which is properly supported in a vertical position and placed with its center in line with the axis of the pivot. In this way the motor shaft causes the mirror to swing back and forth and partake of its movement. To obtain the indicator diagram of the motor it remains to connect the interior of the cylinder so that the gas pressure during the cycle will give a vertical swing to the mirror, and cause the spot of light which is sent from below and reflected upon the screen to trace the diagram. This connection is made by the device seen on the right of the mirror. At 1 is placed a short pipe coming from the motor cylinder and bringing the gas pressure against a diaphragm. Upon this diaphragm rests the piece, 2, which pushes against the lever, 3. At the outer end this lever is pivoted in the supporting block, O, while its inner end is connected to the mirror. In this way the gas pressure against the diaphragm causes the mirror to swing in a vertical direction on each side of the position of rest according as we have expansion or suction in the cylinder. When the pressure of the motor is not acting upon the apparatus, the first-mentioned movement causes the mirror to swing back and forth simply, and the spot of light describes a horizontal line. Throwing on the cylinder pressure, the mirror now takes a vertical swing at the same time, and thus the spot of light traces a diagram analogous to the indicator diagram of a steam engine, showing the relation of the motor shaft's movement and the internal condition of the cylinder.

The above method of transmitting the cylinder pressure to the mirror has been found the best after some experience, as it is very sensitive and the mirror responds readily to the changes in the gas-pressure, even at very high speeds. As the apparatus is constructed, the horizontal lever consists of a half-inch steel rod which has a considerable length from the supporting pivot to the mirror. As to the mirror itself, it is of very light form and is well balanced, so that all the variations of pressure, even where these occur in quick succession, are shown by the spot of light.

A beam of light which is very strong and at the same time has a small section, is obtained by the projection tube seen at *L*. The end of the tube contains a small Nernst lamp, and a diaphragm in the tube gives a very fine beam. The light is strong enough upon the ground-glass screen to allow the diagram to be seen even in ordinary daylight. Photographs can be secured by using a plate-holder which is adapted for the purpose. Owing to the small size of the manograph, it can be mounted directly upon



MANOGRAPH FOR A 4-CYLINDER ENGINE.

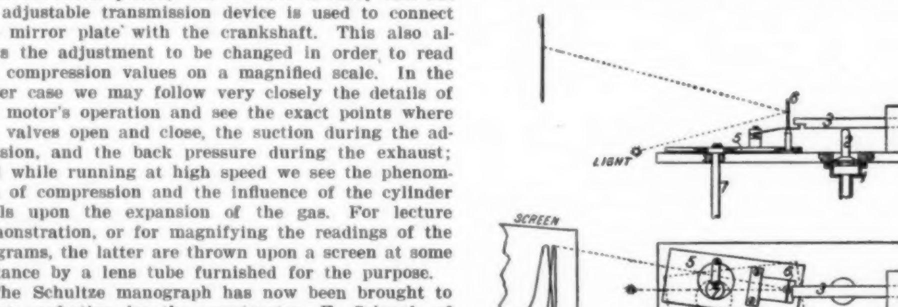
the top of the motor cylinder, and in this way the gas tube can be made very short, thus cutting down the friction losses. Our engraving shows the apparatus as designed for a single cylinder with the gas inlet at *G*, the ground-glass screen, *S*, and the device, *M*, for connecting to the crankshaft. Another view gives an enlarged form, consisting of four such devices mounted together in order to take the diagrams of a 4-cylinder motor at the same time. This latter method gives a great advantage in the study of the motor. The four Nernst lamps are shown at *N*, while the single transmission rod, *P*, goes to the motor shaft.

In order to secure an exact diagram, the movement of the mirror should have the proper synchronism with the motor piston, and in order to carry this out an adjustable transmission device is used to connect the mirror plate with the crankshaft. This also allows the adjustment to be changed in order to read the compression values on a magnified scale. In the latter case we may follow very closely the details of the motor's operation and see the exact points where the valves open and close, the suction during the admission, and the back pressure during the exhaust; and while running at high speed we see the phenomena of compression and the influence of the cylinder walls upon the expansion of the gas. For lecture demonstration, or for magnifying the readings of the diagrams, the latter are thrown upon a screen at some distance by a lens tube furnished for the purpose.

The Schultze manograph has now been brought to great perfection by the constructor, E. Seignol, of Paris, after considerable work upon this instrument, and it has already been applied to a number of motors by the different makers, who are well pleased with its operation and consider that it is a valuable aid in motor designing.

To show how the instrument works in practice we give several diagrams which were taken under different conditions of running. In diagram 1 we have the result found upon a $1\frac{1}{4}$ horse-power gasoline motor. The cylinder bore and stroke are each 2.6 inches, and the motor ran at 1,640 revolutions per minute. The spark lead was 4/5, and the motor operated at full load. The gas admission is shown by the horizontal line *A B*, while the line *B C* gives the compression. Between *C* and *D* the curve shows what happens after ignition of the gas, and the pressure accordingly rises to its maximum at *D*, where it is found to be 240 pounds per square inch. From *D* to *E* we have the expansion of the gas in the cylinder, and the exhaust valve opens upon reaching the point *e* in the curve. Thus we find that the exhaust takes place under very regular conditions from *E* back to the point *A*.

Curve 2 was obtained under the same general conditions of running as curve 1, but in this case the ignition point was set back considerably, and the speed of the motor fell 1,135 revolutions per minute. In this diagram we are able to take a good measurement of the compression in the cylinder. The part of the curve lying between *D* and *E* shows the inflammation of the gas. Curve 3 was made with the same motor as before, but in this case the motor was fitted with cam-operated valves. The test was made to show the values of the compression in the cylinder, and the motor ran without ignition or load, having its shaft coupled to an electric motor which turned up 1,700 revolutions per minute. The diagram allows one to see the compression, expansion, and suction, but upon a larger scale than before, so that the effects can be well observed. At *O D* is the atmosphere line, and the part lying between *A* and *B* indicates the gas admission. Upon the commencement of the ignition the curve shows a pressure of about 140 pounds per square inch. The curve thus shows a defect in these conditions, and we shall see below how this excess of pressure comes about, as it is a disadvantage in the running of the motor. The pressure now falls to the point *d* of the curve. At this point it crosses the atmosphere line and takes a negative direction as far as *d*. From *B* to *C* we have a part of the curve showing an adiabatic compression, and from *C* to *D* we have the expansion which is next produced in the cylinder. A loss of pressure is found here, which may be accounted for by a cooling due to the cylinder metal or to slight leaks either in the cylinder walls or around the piston. At *d* the exhaust valve commences to open and from *d* to *D* we find that the pressure falls. From *D* to *E* is the period of exhaust, with the valve remaining open. By observing this curve we find several points about the working of this motor. A counter-pressure occurs here which shows that the exhaust-valve does not give a sufficient path for the escaping gas, and its outlet surface must be too small. Seeing that the exhaust valve closes at the point *E* when the pressure in the cylinder is greater than atmospheric pressure, the pressure rises in the cylinder up to the end of the stroke. This accounts for the excess of pressure which we found at *A* at the beginning of the operation.



INDICATOR DIAGRAMS TRACED BY THE MANOGRAPH.

Curve 1 shows normal conditions and full load; curve 2, late ignition; and curve 3, running light without a load.

THE RECENT DETERMINATION OF THE FIGURE AND SIZE OF THE EARTH FROM MEASUREMENTS IN THE UNITED STATES.

A PAPER on the above subject was read by John F. Hayford, Inspector of Geodetic Work and Chief of the Computing Division, Coast and Geodetic Survey, Washington, D. C., before the Mechanical Science and Engineering Section of the American Association for the Advancement of Science, at the New York meeting, December 28, 1906.

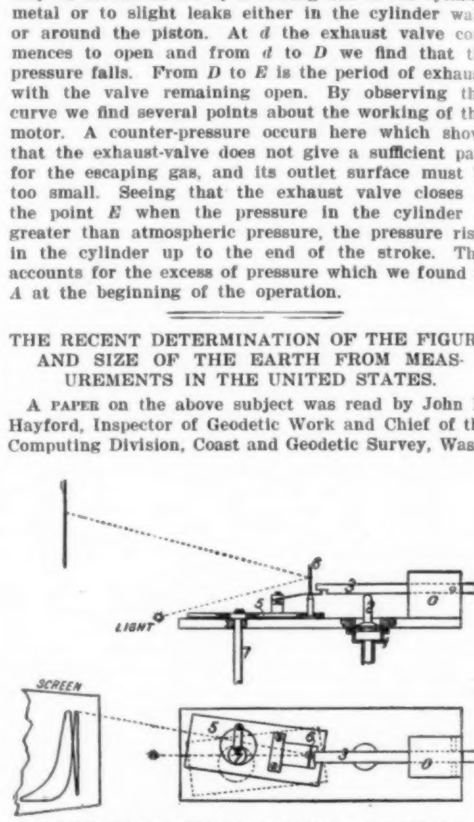


DIAGRAM SHOWING CONSTRUCTION OF THE SCHULTZE MANOGRAPH.

The investigation of the figure and size of the earth to which the paper referred is interesting because it involves radical and successful changes from the methods heretofore used in geodesy, because it furnishes a proof of the weakness of the material composing the earth, and because it constitutes an unusually large contribution by any one nation to the problem of determining the information sought.

It is based upon 507 series of astronomic determinations made at many different stations, and upon continuous triangulation extending from the Atlantic to the Pacific, and from the Great Lakes to the Gulf of Mexico.

The investigation shows that, for the United States and adjacent areas, the assumption sometimes tacitly made that the material composing the earth is sufficiently rigid to maintain the continent in position, in the vertical sense, is far from the truth. On the contrary, the assumption that the earth is in the condition called isostasy is a comparatively close approximation to the truth. In other words, the United States is not maintained in its position above sea level by the rigidity of the earth, but is, in the main, buoyed up, floated, because it is composed of material of deficient density.

It was also ascertained that this material of deficient density probably extends to a depth of about seventy miles below the surface.

The flattening of the earth, according to this investigation, is between the values assigned by Clarke and Bessel. Both the equatorial and the polar dimensions are found to be larger than they were stated to be by Bessel or Clarke, or any of the other principal investigators along this line.

HYBRIDIZATION OF THE OAKS.*

By DR. D. T. MACDOUGAL.

THE number of forms of plants which have been or are regarded as hybrids by systematists is a large one, and includes several oaks, of which two have been examined in the last two seasons. Attention has been previously called to the untrustworthiness of the custom prevalent among botanists of attributing a hybrid origin to certain plants because they appear to exhibit halved, fused characters or a mosaic of qualities derived from the two supposititious ancestors. In some instances such deductions have been made by which the ancestry of a questionable plant has been made to include three or even four species. The argument of distribution is the main one offered in such attempted demonstrations. In some instances, this together with other circumstantial evidence may amount to almost positive conviction, but unless this close relation of well-joined facts is furnished, assertions as to the hybridity of a plant must be taken simply as a suggestion to be tested by cultural or experimental methods. A review of the literature concerning the flora of North America made by Mr. D. S. George in 1903 brought to light references of the above character affecting many genera and species of seed plants.

When confronted with a supposed plant of this character, three methods of attack are available to the investigator: that of obtaining the supposed hybrid by synthesizing it from its supposed parents; that of making an anatomical examination of the hybrid and the parents to which it has been referred; and that of obtaining second, third, and succeeding generations of the hybrid for the purpose of ascertaining whether or not any separation of the ancestral characters may occur in an alternative inheritance, by which the ancestral forms may actually reappear. All of these methods are beset with numerous difficulties, but when used together with the facts of distribution a very satisfactory degree of proof may be obtained.

The re-formation of a hybrid by the cross pollenation of the parents to which it may be ascribed is by no means simple in all instances, nor is it always easy of accomplishment. In the first place the original cross pollenation may have possibly taken place under an exceedingly rare combination of favorable physiological conditions difficult to secure or duplicate in experimentation. Then one or both of the species as ordinarily recognized may in reality consist of two or more elementary species, which may not differ widely in external anatomical characteristics, but which may offer widely divergent physiological characters and behave quite differently in breeding. A hybrid with one of these forms may differ in very many important particulars from a hybrid with another constituent of the same species. Of course if we deal with elementary species only in our usage of the term this difficulty does not exist, but it does appear as a serious matter with the customary practice, as has been found in a number of breeding experiments, and furthermore must be taken into account no matter by what method we consider a hybrid.

Let us suppose, however, that we have actually in hand the two strains or elementary species by which the hybrid may have arisen, and we have still one more matter which may mislead us. This consists in the fact that reciprocal crosses are not always identical in their products. Thus the pollen of A and the egg of B do not give us the same hybrid as the egg of A and the pollen of B.

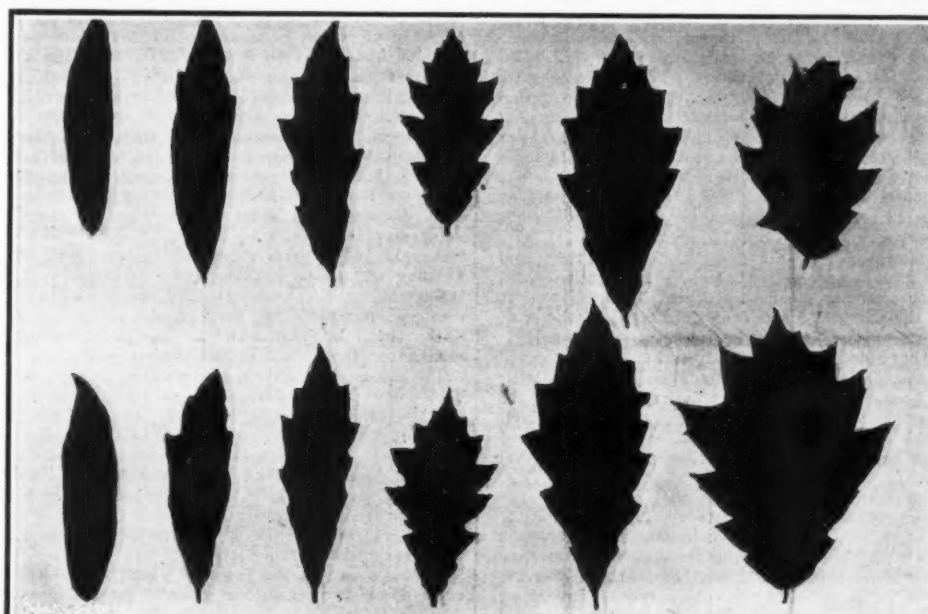
The pollenation of *Oenothera Lamarckiana* by *O. biennis* generally results in securing a progeny separable into seven types, some of which are fixed and reproduce themselves exactly in succeeding generations, while others split into two or more forms in the second generation. On the other hand, the use of pollen of *O. Lamarckiana* on pistils of *O. biennis* results in a progeny embracing four types, none of which is identical with the components of the reciprocal cross. *O. biennis* shows a similar behavior in some other crosses in the limited observations recorded. In all such cases it must be understood that the number of types does not appear to be fixed, and that a progeny of a hundred thousand is likely to include more than one of a score. It is evident that in the determination of a hybrid by this method difficulties may be met with. Thus failure of the operator to secure the supposed hybrid may not be considered as proof that it may really have come by one of the rarer combinations which he has missed. On the other hand, success may come with the first cross and in the first generation.

In some instances the result of a hybridization is a single type which offers the qualities of the parents locked in a stable combination in the first generation, and reproducing without separation in successive generations. It is this type of hybridization that is implied in the general assertions as to the hybrid origin of any plant, and it is a type of which we have the fewest illustrations in breeding experiments.

To recur again to the genus furnishing the example previously given, *O. cruciata varia* was suspected by the author to be a combination of *O. Lamarckiana* and *O. cruciata*, and in the synthesizing test the good fortune was encountered of selecting the one of the three known elementary species of *O. cruciata* which had originally entered into the union. The egg of *Lamarckiana* and the pollen elements of this form entered into a stable combination which has the distinctness and fixity of a species, and as a matter of fact this hybrid has been long mistaken for the true *O. cruciata* by a great number of European gardeners and botanists.

In addition to the difficulties of hybridization and interpretation of the results described above, it is also to be taken into account that in some instances a long period ensues between the act of pollenation and the perfection of the fruit, and then a long time is necessary for the germination of the seeds and development of the progeny. Ten, fifteen, or even twenty years might be necessary to make an application of this method to some of the species of trees, which would obviously make it unavailable except under extraordinary circumstances.

The examination of the anatomical characters of a plant to determine its ancestry is a method which has become of less esteem in the light of modern additions to information as to the character and behavior of hybrids. Of the various types of hybrids described, it is of course the fixed hybrid which is most likely to come under examination; and while it occasionally presents a fair average of the characters of the parent, yet more frequently it is goneoclinic to one or the other, and may be so near one parent that a gross or minute estimation of the tissue structure would offer nothing better than a guess as to the other parent, a guess which might be fortified to some extent by the facts of distribution perhaps. In certain meristic qualities such as the rate and total amount of growth the hybrid may even exceed that of either parent or be less than either.



1. 2. 3. 4. 5. 6.

HYBRIDIZATION OF THE OAKS.

The mistaken impression prevails that hybrids bear defective pollen, but this is generally found to be the case only when the cross is unbalanced in many characters, particularly those appertaining to the reproductive functions. The infertility of many animal hybrids has also strengthened the assumption that plant hybrids share this defect. Many hybrids are quite as prolific in mature seeds as either parent, while in some that are offered by the seedsman and nurseryman they are claimed to excel in this respect.

In any case where the comparative anatomical method is used care must be taken to make observations upon material from similar stages of development. This is forcibly impressed upon one after following the growth of a hybrid which in the seedling stages shows a predominance of the qualities and anatomical characters of one parent, a different arrangement in the adult shoot, and a still different balance in the flower and fruit.

The third method of study of a supposed hybrid is one which involves pure cultures of its progeny for one or two generations. If it should be a fixed hybrid no results will be secured which will be of value in the solution of the problem, since so far as any facts offered by such cultures are concerned the plant behaves as any other species. Presumably most of the species of suspected hybrid origin are of this character, but some of them will be undoubtedly found to be constantly re-formed and to offer alternative inheritance, and hence this test should be applied whenever practicable.

If the supposed parents differ in but one or a few characters and the hybrid shows alternative inheritance, the solution of the main question lies near at hand. It is not such simple questions as this, however, that we are usually called upon to solve. The real difficulties lie with hybrids with the component qualities in stable combination making a fixed hybrid, and with the forms which exhibit an interlocked combination of the ancestral characters in the first generation which resolve into the possible combinations of the dissimilar characters in the second, by which an enormous range of individuals is presented, which without close examination of a large progeny might appear to be a hopeless medley. This is best illustrated by a plant which has been recently studied in cultures at the New York Botanical Garden and at the Desert Laboratory—Bartram's oak, *Quercus heterophylla*.

Bartram's oak was discovered as a single individual growing on the farm of Mr. John Bartram near Philadelphia, on the banks of the Schuylkill, at some time previous to 1750. A rather complete history of the occurrence of other individuals which were included with this tree under the name of *Q. heterophylla* is given by Dr. Arthur Hollick in the Bulletin of the Torrey Botanical Club for 1888 (15:303. 1888) and need not be repeated here.

After a consideration of various lots of material which appeared to differ widely, various botanists have regarded this tree as a hybrid between *Q. Phellos* and *Q. tinctoria*, *Q. Phellos* and *Q. falcata*, *Q. Phellos* and *Q. coccinea*, *Q. Phellos* and *Q. palustris*, while others have designated it as a variety of *Q. Phellos*, *Q. coccinea*, *Q. aquatica*, *Q. nigra*, and *Q. imbricaria*. It is notable that of the botanists who ascribed a hybrid origin to the plant, all agreed that *Q. Phellos* must be one of the parents, a fact which will be easily explainable when an examination of its leaves is made.

In October, 1905, the author was accompanied to a locality on Staten Island by Dr. Hollick and Dr. Britton, where several trees of the species had been under observation by them for many years. About 75 acorns were procured from a tree which bore leaves of a form approximating that of *D*, Fig. 3, and were placed in the propagating houses of the New York Botanical Garden, with the result that 55 plantlets were available for study in December and January following. With the formation of the earliest leaves it became evident that a wide diversity of form of these organs and of other qualities prevailed, as shown by the photograph taken in April.

In May, 1906, all of the plantlets were transferred to a plantation in the experimental grounds, and as development proceeded the diversity became still more marked. At the close of the season it could be seen that this group of plants included some which simulated *Q. Phellos* with its lanceolate entire leaves, while others were not separable from *Q. rubra*, the remainder being capable of arrangement in a series between these two poles. An examination of the literature disclosed the fact that the combined observations of the several botanists who have written on the subject refer to plants bearing almost the entire range of leaves noted in the cultures here described. In most of these accounts the leaves are said to be much like those of *Q. Phellos*, while some observations include notices of others which were broad, lobed, and notched, although most of these writers were extremely chary of identifying any of the forms with those of *Q. rubra*. It is to be noted, however, that as a result of the consideration of gross anatomical facts and distributional data, Dr. Hollick and other botanists had finally concurred in the general conclusion that the tree was in all probability a hybrid between the red oak and the willow oak.

With our present available information concerning the behavior of hybrids this conclusion seems unavoidable. If we attempt to follow out the history of the hybridization as it may have occurred, however, we are compelled to rely upon inference in part. The actual nature of the immediate product of the cross is not known. The parental species have undoubtedly sustained similar distributional relations to each other for uncounted hundreds or thousands of years, and there is no reason to suppose that hybridization may

* Paper read before the American Association for the Advancement of Science.

not have taken place many generations ago. On this account it is not possible to say whether the tree from which the germinated acorns were taken was the immediate product of the cross or whether it is the n^{th} generation of its progeny.

In balanced crosses in which the parents show a large number of dissimilar characters the first generation rarely offers the spectacle of pure dominance of the characters derived from one parent and recessiveness of those from the other parent. It is only when the parents differ by a point or two that such total dominance is seen and the first generation or the immediate product of the cross resembles one parent or the other, and its progeny split in the next generation. In cases such as that under discussion, and which is also illustrated by the walnuts, the first generation shows a mixed dominance as well as a possible fractionization of some meristic qualities, so that the hybrid appears as an intermediate between the two parents, toward both of which its relative position may be variously estimated. In the second generation the movements of the recessives coupled with the range of fluctuating variability should give a wide diversity of types, varying in number with the number of differentiating points of the parents of the cross, which may include both parents, the type of the first generation, and an intricately interwoven connecting series of forms.

By reason of the number of dissimilar characters involved in such a cross the probability of deriving an individual composed entirely of recessive characters or of the particular combination characteristic of either ancestor is very small. A progeny of hundreds of thousands of species would be necessary to furnish a series inclusive of both ancestors and intermediate combinations.

While it may not be said that any of the plantlets of the progeny under observation are reconstituted ancestral forms, yet some of the individuals include so many of the qualities of the red oak and willow oak that the evidence is overwhelmingly in favor of the conclusion that the origin of *Q. heterophylla* is to be attributed to the hybridization of these two forms. Taking this conclusion as established, it may then be said that the name *Q. heterophylla* is at present applied to a medley of oak trees which possibly includes the first generation of a cross between *Q. rubra* and *Q. Phellos*, secondary hybrids with either parent, as well as successive generations in which various combinations of ancestral qualities may appear.

Another aspect of the parental form of the above hybrid and the progeny remains to be mentioned. A collector covering the field occupied by the hybrid in which the parental forms come into contact, who gathered a full series of material from the trees available, would have data upon which mistaken conclusions as to intergradation of species by fluctuating variability might be made. This leads to the suggestion that any supposed intergradation of two species of seed plants should be examined with respect to possible hybridizations before any final estimate is reached in the matter.

Furthermore, it is to be seen that while in all reasonable probability opportunity for hybridization between these two oaks has been present for a period of unknown but undoubted great length, yet it has not resulted in anything in the way of occurrence or distribution suggestive of the disappearance of either parental form. The probably greater frequency of intra-specific fertilization over hybridization would secure this result. Then again it is to be seen that even in the case of complete cross fertilization of all of the individuals, there would be the probable reconstitution of the ancestral forms among the progenies.

Quercus Rudkini has long been reputed to be a hybrid between *Q. Phellos* and *Q. Marylandica*, and a visit was made to the group of trees from which the species was originally described by Dr. Britton, in company with him and other botanists in October, 1905. These trees stand near Keyport, N. J., and since the original discovery in 1881 others have been found on Staten Island and also to some distance to the southwestward in New Jersey. The mere facts of distributional relations together with the anatomical features offered by the bark and leaves led to the description of these trees as being of a hybrid origin from the willow oak and the black oak. If these facts only are taken into account, it seems quite as plausible to regard this tree as a hybrid of *Q. heterophylla*. The leaves taken from the included trees showed a range of forms that included the type of *Q. Phellos*, but did not go wide enough to show duplicates of those of the other parent as described and figured by Dr. Britton (Bull. Torr. Bot. Club, 9:13:1882). The acorns likewise ranged from the form near that of *Q. Phellos* toward *Q. Marylandica*, but included none that might be mistaken for the latter. The bark of the various individuals on the other hand seemed most like *Q. Marylandica*, although much variation was apparent.

During the visit of 1905 acorns were found on trees of some of the types only, and material capable of germination was obtained from three of them. When these were at the end of the first year's growth, which began in the propagating houses in January in 1906 and ended in September, it was seen that the progenies of the three parents, selected for their dissimilarity, were fairly identical; and while a wide range of variability was found, yet this range did not exceed the limits of similar fluctuations offered by other species of oaks which are known to be unified hereditary strains.

The leaves of these seedlings did not include forms which might be mistaken for those of either parent. It is to be seen therefore that the cultural observations revealed no evidence to show that Rudkin's oak is of hybrid origin, although it did not disprove it. Synthetic tests, which take much time, and detailed anatomical examinations are yet to be resorted to. It is quite possible that the group of trees examined may represent some segregation of the ancestral qualities and not the full range of combinations discovered in *Q. heterophylla*. Meanwhile this oak, which is thus constant in successive generations within the limits of its variability, must be regarded as a species in accordance with current taxonomic practice, until some positive evidence to the contrary is obtained.

The principles illustrated by the foregoing facts may be briefly summarized as follows:

It is obvious that the facts of geographical distribution may be relied upon to furnish conclusive evidence as to the origin of a species or a hereditary quality only under very exceptional conditions in which other possibilities are excluded, and then only in a circumstantial manner. It is of course a basal and necessary fact that species not in contact may not hybridize, but the converse is true only when otherwise proven.

So far as the plants of suspected hybrid origin from parents suggested by distributional relations are concerned, the methods of investigation available are two, which may separately secure affirmative evidence of conclusive value, while the third may bring no more than confirmations and suggestions.

Attempts at synthesization, if successful, yield dependable conclusions as to the composition of a hybrid, yet a failure to secure a form by synthesis may be due to innate and almost intangible difficulties in the hybridization of the forms concerned, by the different results of reciprocal crossing and the difference in physiological attributes of elementary species included under one name. Furthermore, the natural form the ancestry of which is under search may have been a derived hybrid which became fixed in the n^{th} generation by a fortuitous combination of dominant characters. To secure a similar result in an experimental test might be beyond the range of probability.

In an anatomical examination such a combination of dominant and recessive characters with fluctuations in meristic characters away beyond either parent may make the results of but little value until confirmed by data derived from other sources, before their full value may be known.

A study of a fixed hybrid by cultural tests of its progeny will reveal nothing as to its origin, and synthesization and anatomic examinations are the only recourse. On the other hand, if the progeny exhibits alternative inheritance, its components may show unmistakably the nature of the original cross.

The last-named method demonstrates beyond reasonable doubt that Bartram's oak is a hybrid derivative of the willow oak and red oak, the progeny being probably characterized by alternative inheritance of some of the qualities, and fractionization of others instead of being a unified hereditary strain. Some of the plantlets included in a progeny of 55 individuals were apparent re-constitutions of the ancestral types as observed at the close of the first year, while others were variously intermediate.

Rudkin's oak on the contrary yields no evidence in cultures of its progeny on which a defensible conclusion as to its origin may be based. The individual variability of the trees included under this name is very great, and some of these approach the willow oak in leaf form, and some of the characters of the acorns. The study of over a hundred plantlets showed a wide and practically identical range of variation. Alternative inheritance could not be traced. The individuals known under the name of *Q. Rudkini* produce a large proportion of imperfect acorns, but beyond this no facts suggestive of hybrid origin can be found, except the anatomical resemblances noted.

A list of the natural plant hybrids of North America was prepared by Mr. David George for presentation at the International Hybrid Conference in New York in 1902 but was not published. In this list it was noted that 117 natural hybrids had been reported as occurring in the indigenous flora of North America, in addition to some instances among the ferns and mosses. The manuscript having been placed at my disposal by the director of the New York Botanical Garden, a revision of the list has been made, some of the original references being omitted and a few added. No attempt has been made to make it actually complete, the sole purpose being to suggest material for extended observations similar to those described in this paper.

The reported hybrids are distributed among the natural families as follows:

Naidaceæ. Two cases in *Potamogeton*.

Cyperaceæ. Twelve hybrids in *Carex*.

Juncaceæ. One hybrid, between *Juncus effusus* and *J. Pacificus*.

Liliaceæ. One hybrid between *Calochortus Benthami* and *B. albus*.

Orchidaceæ. One hybrid between *Habenaria lacera* and *H. psycodes*.

Juglandaceæ. Three hybrids of *Hicoria pecan* with *H. minima*, *H. alba*, and *H. laciniosa*.

One hybrid between *Juglans nigra* and *J. cinerea*.

Salicaceæ. About twenty supposed hybrids of *Salix* are noted.

Two hybrids of *Betula* are also reported between *B. pumila* and *B. lenta* and between *B. populifolia* and *B. papyrifera*.

Fagaceæ. Thirty-five oak hybrids have been reported, but one of these, *Q. Rudkini*, has been tested as described above with negative results.

Ranunculaceæ. A hybrid between *Actea alba* and *A. rubra*. *Clematis viornoides* is reported to be of a hybrid nature.

Cruciferæ. *Roripa palustris* is supposed to form natural hybrids with *R. obtusa* and *R. sinuata*.

Pomaceæ. *Malus Soulardi* is taken to be a cross between *M. coronarius* and *M. Malmus* by some workers.

Rosaceæ. *Geum strictum* and *G. Canadense* are supposed to form a hybrid.

*Papilionaceæ. A hybrid between *Baptisia australis* and *B. bracteata* is reported.

Anacardiaceæ. *Rhus hirta* is supposed to cross with *R. glabra*.

Rhamnaceæ. *Ceanothus Lobbianus* is taken to be a hybrid between *C. thyrsiflorus* and *C. dentatus*. It is also supposed that *C. thyrsiflorus* hybridizes with *C. papillosus* and *C. sorediatus*.

Violaceæ. A large number of hybrids of *Viola* have been reported.

Onagraceæ. *Oenothera biennis* and *O. Oakesiana* hybridize, the progeny of the first generation consisting of several types.

Cactaceæ. A hybrid is supposed to be formed between two species of *Opuntia*.

Cornaceæ. *Cornus Baileya* has been taken to be a hybrid between *C. asperifolia* and *C. stolonifera*.

Verbenaceæ. The evidence seems strong that *Verbena Canadensis* and *V. bracteosa*, *V. bracteosa* and *V. hastata*, *V. bracteosa* and *V. urticifolia*, *V. bracteosa* and *V. stricta*, *V. stricta* and *V. hastata*, *V. stricta* and *V. urticifolia*, *V. urticifolia* and *V. hastata*, *V. angustifolia* and *V. stricta*, and *V. angustifolia* and *V. bracteosa*.

Acanthaceæ. *Ruellia ciliosa parviflora* has been supposed to be the result of a cross between *R. ciliosa* and *R. strepens*.

Lobeliaceæ. *Lobelia syphilitica* is supposed to hybridize with *L. cardinalis*.

Cichoriaceæ. *Prenanthes Mainensis* is taken to be a cross between *Nabalus racemosus* and *N. trifoliatus*.

Compositæ. Hybrids are reported in *Eupatorium*, *Solidago*, *Aster*, *Bidens* and *Helenium*.

The genera noted above are supposed to offer about two hundred hybrids; and as the observations have been made principally with the flora of eastern North America in a region which probably does not furnish more than twenty thousand species, it is to be seen that the questions involved affect about one per cent of the flora. Probably not more than half of the instances included in the above list could be confirmed by actual tests, but on the other hand it is probable that a closer examination would reveal an equal number of actual occurrences.

Some of the constituents of the native flora are known to be constant unitypic hybrids, and hence have every claim to be regarded as species. The type of hybridization most widely different from this is illustrated by Bartram's oak, and between these two diverse modes of action may be found. In gaining a more extended and accurate knowledge of the manner in which the qualities of separate unified strains of plants are alternative, or are interlocked, or fractionized in hybridizations, a vantage ground will be gained for the consideration of all questions in genetics as to saltations, minute accretions, and fluctuations of such characters.—Botanical Gazette.

THE FEAR OF OPEN AND CLOSED SPACES.

By Charles Mercier, M.D.

Agoraphobia, or fear of open spaces, is not nearly as common a malady as its antithesis, claustrophobia. Both are curious, and somewhat anomalous, states of mind, in which an aversion, which is known and admitted by the subject of it to be irrational and absurd, nevertheless dominates conduct, prompts the execution of irrational acts, and renders certain rational and desirable acts impossible.

If I had to speculate on the origin of these curious and spurious instincts, for such they may be termed, I should assign them to the revival of instincts which existed in full force, and had great biological value, in our remote ancestry, but which in most of us have long been obsolete. When our ancestors were arboreal in habit, this habit was their salvation from extinction. Feeble in body, destitute of weapons and of defensive armor, devoid of means of concealment, their safety from carnivorous foes lay in the agility with which they could climb out of reach, and in the accuracy with which they could leap from bough to bough and from tree to tree. Whenever they descended to the ground, they were in danger. It is on the ground that the greater carnivora pursue their prey; and, adapted as our ancestors were to arboreal life, their progress on open ground was undoubtedly less rapid than among the tree tops, and most probably less rapid than that of their principal foes. Among the tree tops they were secure. There, no enemy could vie with them in activity, or hope to overtake them; but on the ground they were at a disadvantage. On the flat, they had no chance against the spring of the panther or the speed and wind of the wolf; but once let them attain the security of the forest, and they could grin and chatter with contempt at their helpless enemies below. The farther they ventured from their secure retreat, the greater the peril they were in; the nearer their refuge, the more complete their sense of security. Since instincts, using the term in the sense of mental cravings, become adapted to modes of life, which, in turn, they dictate, we may be sure that, in the arboreal stage

of their existence, our ancestors had a very strong instinctive aversion to any extended excursion from their place of security and refuge. Near to trees, they were in safety; far from trees, they were in continual danger, and therefore in continual uneasiness. In such a situation they had an abiding and well-founded dread and sense of impending danger.

This is the state of mind which, as it seems to me, is reproduced in similar circumstances in agoraphobia. The craving of the subject of this malady is to be near, not trees necessarily, it is true, but near to some tall vertical structure. Away from such a structure, he has just the feeling of dread, of impending danger, of imminent disaster, of something dreadful about to happen, that a man would have who was walking through a jungle infested by tigers, or that a child has when alone in the dark. And this is just such a feeling as we may suppose our arboreal ancestors had when they were out of reach of their natural habitat. I have seen a woman affected with agoraphobia get from one side of a court to the other by not only going round by the wall, and touching it all the way, but squeezing herself up against it, and clutching at the bare surface. Sufferers from this malady cannot cross an open space. They cannot venture more than a step or two from some vertical surface. They feel no uneasiness in a colonnade, open all around them though it be. Their reason tells them that their dread is groundless, but reason is powerless against instinct, and an imperious instinct shouts danger in their ears.

The opposite malady—claustrophobia—seems to me to reproduce a state of affairs of much later occurrence in our racial history. When arboreal habits at length began to be abandoned, and our anthropoid ancestors began to shelter themselves in hollow trees, in caves, and holes in the ground, there must often have been a conflict between the immeasurably old, primitive habit of roosting under the open sky and the modern innovation of taking shelter from the weather. The sense of confinement must have been very irksome. We may be sure that there was no sudden revolution in the mode of life. The new habit was adopted very gradually. Only in some very violent storm would the first indwellers creep into a hole for shelter, and they would soon find their circumscribed quarters intolerable, and brave the elements as soon as the weather began to moderate. Perhaps the new instinct was first implanted in the young, by the parents bestowing their tender offspring in holes during their own absence or when cold and rain became severe. It is not easy to teach an old dog new tricks; but a young wild rabbit or squirrel, taken at a very early age from the nest, never acquires the untamable wildness that is so conspicuous a feature in the character of the old. In any case, the habit of taking shelter in more or less closed spaces was a habit of slow and gradual acquirement; and we may be sure that it was not acquired without many a relapse and many a backsliding. We can almost hear the jeers and scoffs of the stout old Tory anthropoids at the effeminacy of their degenerate juniors, who should seek a shelter that their forefathers would have scorned. The habit has not yet been fully acquired by all our race, for we see, even at this late day, many persons of human status to whom the shelter of a roof is abhorrent, and who prefer, in the worst of weather, to lie out under a hedgeside rather than submit to the restraint of roof and walls.

It is to the imperfect acquisition of this later instinct of seeking shelter in confined spaces—or rather it is to the re-assertion over it of the more remote and earlier instinct of craving for the open sky, and irksomeness of confinement—that the malady of claustrophobia seems to me to be due. In the subject of this malady is revived in its original strength that craving for open sky and open air, for possibility of movement in every direction, which were ingrained in our ancestors by their free arboreal lives; and which were overcome with such difficulty when first they descended to inhabit *terra firma*. Like the sufferer from agoraphobia, he who suffers from claustrophobia experiences the revival of an ancestral instinct that has been obsolete for untold generations, but that has been lost more recently than that revived in agoraphobia. Since it existed down to a later date; since it has been more recently lost, it is more easily revived; and this is the reason, I think, that claustrophobia is so much less rare than agoraphobia.—London Lancet.

ATMOSPHERIC DUST.

THE importance of dust in the economy of the atmosphere is not to be underrated, but neither should it be overestimated. If dust is present in the air, the light reflected therefrom has various tints of gray or red, depending on the size and nature of the particles of dust, but if no dust is present, light may be reflected from any minute particles of water or ice that happen to be present, and these are not generally called dust. Molecules of water or ice sometimes form minute drops by gathering about particles of dust as nuclei, but they can also form such drops without dust as nuclei, and must frequently do so. However, if neither dust nor water were present in the atmosphere, we should still have our ordinary blue sky light, and some sunset sky colors. The deep blue of the sky is due almost entirely to the selective dispersion of the various waves or rays of light that come from the sun, by the action of the molecules of the constituent gases of the atmosphere. The ability of these molecules to absorb and reflect any given wave length depends upon the relative dimensions of the wave and the molecule. The exact relation has been carefully worked out by Lord Rayleigh, whose formulæ explain not only the blue color of the sky, but also the polarized condition of that light. Dust particles and ordinary water or ice particles are relatively so large that they reflect all rays of light, with a slight possible predominance of the red rays or long waves; consequently the hazy whites and grays of foggy weather and the dirty reds of the Indian summer may be attributed to dust and vapor, which in fact obscure the deep blue sky light.

Aqueous vapor in its finest condition, when it begins to condense without the help of dust nuclei, has the power of selectively reflecting the longer or bright blue as distinguished from the shorter dark blue of the pure upper sky; the resulting bluish haze may often be seen under favorable atmospheric conditions when we look at a distant landscape, and especially in the pure air of oceanic islands. The blue haze off the west coast of Scotland is proverbial. This haze was first studied in the laboratory by Tyndall, when he produced it unexpectedly by allowing dustless moist air to expand inside the vacuum tube.

The beautiful colored sunsets observed in connection with the eruption of Krakota, and especially the brilliant colors brought out by Prof. Carl Barus, of Brown University, in his study of cloudy condensation, are not due to dust nor to the selective reflection by fine particles, but are examples of a very different process, i.e., the colors of thin plates, or what Newton called the colors of thin films. The central portion of each little sphere of water transmits a minute beam of sunlight which has been reflected to and fro within the sphere, and its waves have interfered with each other. Some have been reinforced and others have been annulled. The former give the beam that is seen by the observer, and its color depends on the diameter of the sphere or the thickness of the film of water.

In general, therefore, our beautiful atmospheric colors are not altogether due to dust.—Monthly Weather Review.

TRADE NOTES AND FORMULÆ.

Zwieback Extract.—It is stated that these extracts, which are said to be of Dutch origin, contain a large quantity of soap. This admixture of soap is probably intended to produce the flaky, frothy dough so greatly valued in biscuits and zwieback, and these extracts are expressly recommended for use in the baking of the latter.

Heated Circular-Saw Blades.—Circular-saw blades that have run hot should not, as the Allgemeine Tischlerzeitung observes, be cooled with cold water, as they are liable to warp or become distorted. The cooling must be gradual; the saws should be allowed to run free for at least five minutes, and then gradually to stop of their own accord. Only in extreme cases may an attempt be made to accelerate the cooling process by the admission of air.—Neueste Erfin. u. Erfahr.

Practical Directions for Making Ink Eradicators.—Dip a thick piece of white absorbent (blotting) paper into a solution of 100 parts of oxalic acid in 400 parts of alcohol; keep the paper in the liquid until it is thoroughly saturated, and then dry by suspending in the air. Aniline ink spots cannot be removed by this paper. Since, however, ink containing iron is much more commonly used than aniline ink, this paper will be found indispensable for the office when once introduced.—Neueste. Erf. u. Erfahr.

To Make Varnish for Roofs.—The following recipe for preparing varnish for roofs is given by the Erste österreichische Dachdeckerzeitung: 700 parts by weight of distilled coal-tar are heated in a boiler and 70 parts degras added when the tar is still liquid. This should be constantly stirred, and a mixture of 175 parts by weight of washed brown-coal ashes, 20 parts of flowers of sulphur, and 35 parts of alum gradually added. The varnish is applied hot, like other varnishes. Sanding the roof does not appear necessary, as the varnish dries quickly and will not drip off.—Neueste Erfindungen und Erfahrungen.

A Paste Which Will Adhere to Tin.—According to a communication to the Apothekerzeitung, Lemoine prepares a paste which will adhere to tin by mixing 2 parts of tragacanth powder with 16 parts of boiling water, vigorously stirring the liquid and allowing it to settle. A mass is made, at the same time, of 4 parts of cold water, 6 parts of rye flour, and 1 part of dextrine and added to the tragacanth solution. This liquid is then mixed with 24 parts of boiling water, stirring constantly, and further with 1 part of glycerine and 1 part of salicylic acid; the whole mass is next boiled for three to four hours, stirring as before. This mixture is somewhat complicated. I have found that ordinary starch paste, with the addition of some glycerine, also possesses the property of adhering to tin, and this simpler compound will probably suffice for most purposes.—Neueste Erf. u. Erf.

To Clean Marble Slabs.—Though we have on a previous occasion given directions for cleaning marble, we must not omit mention of some new information on this subject communicated to the Pharmazeutische Post by the engineer and chemist, A. Gawalowski. Grease spots may be covered to the thickness of the little finger with a paste made of magnesium and benzine, and the dried magnesia crust removed in one to two hours. Extract spots can be removed in the same manner by a paste composed of talc, fibrous gypsum, lemon juice, citric acid, and tartaric acid or oxalic acid with alcohol and diluted. Or a bleaching paste is made from barium peroxide and dilute sulphuric acid, mixing these ingredients at a very low temperature and avoiding acid reaction, i. e., excess of sulphuric acid, and applying as above. According to Gawalowski, calcium peroxide, magnesium peroxide, or zinc peroxide answers the same purpose. The marble is afterward polished with putty powder and paraffine oil.

ENGINEERING NOTES.

The treatment of unsuitable feed water for locomotive use has long been recognized as a necessity, and crude methods with such practical means and facilities as have been available, have been practised for many years. With the increased capacity of locomotives, the amount of water evaporated and the supply of water required has resulted in the necessity for improved apparatus and storage capacity to provide for such chemical treatment, which, combined with mechanical means, will produce the best results.

An iron smelting plant having steam turbines and gas fired boilers in the power station may at present consume all of its available gas in the blast furnace and steel works. If a corresponding allotment for rolling mills is to be added, or if other industries are attracted to settle in the neighborhood, or if some community or city would build up in the immediate vicinity of the plant to whom it might be desirable to sell power at a profit, then the works management would be confronted by the necessity of either buying good steam coal, or else of consigning steam turbines and boilers to the scrap heap and of replacing them by gas engines able to generate the required additional energy from the available gases or other waste at no additional cost.

The fact that the compound can be replaced by the simple locomotive, with increase of power and low pressure in the boiler, is an advantage of superheated steam, even if no economy in fuel is obtained. As superheated steam applied to locomotives gives a higher thermo-dynamic efficiency than that realized from compound locomotives using saturated steam, it will enable the possibility of obtaining the advantages of compounding, without the introduction of the objectionable features. The possibility for increasing the capacity and economy of present locomotives by superheating is of even greater importance, as boilers which may be deficient in design or capacity can be much improved in effectiveness, and superheaters can be applied without altering the general design or construction of the boiler or mechanism.

The conditions which will beset the engineer of the twentieth century will be exacting beyond anything we now know. The importance of a strong foundation in scientific principles cannot be overestimated, for scientific principles are only the laws of nature. These principles cannot be learned readily after a man has begun his life work. His whole energy will then be devoted to applying these principles correctly, not in acquiring them laboriously. It will be a prime necessity for the technical college of the future to lay these foundations broad and deep. It will be regarded as a weakness for a college to teach its students only the knacks of the profession, only just enough to be an ordinary draftsman, a tolerable surveyor, or first-class linesman.

It sounds a strange thing to say that good drainage is in some degree synonymous with good dividend. In all civil engineering work, however, judicious first cost and the exercise of skill in properly dealing with water ultimately saves much money in maintenance. Most of the ills the civil engineer is heir to are attributable to the effects of water; and from the point of view of the economies of the maintenance of works, water may be described as the greatest of the forces of nature with which the civil engineer has to contend. The debit of maintenance and revenue account in respect of remedial work necessitated by the action of water is enormous; young engineers should mark specially, and inwardly digest the saying attributed to a well-known Scottish contractor of the recent past: "Ye canna cheet watter." Never was there a saying more true. It is not so much the impetuous flood and the flowing tide that one has to guard against, and never forget, in the design of works from the point of view of maintenance, but rather the terribly insidious and stealthy action of water, which never stops, and which inevitably results in decay as silent and as certain as the grave.

An invention which will prove of widespread utility to the textile industry has recently been devised conjointly by three English engineers for tow-carding upon an extensive scale. The machine is essentially of the labor-saving class, it being possible to accomplish as much therewith as has hitherto required fifteen hands. Tow, the by-product of flax, has heretofore always necessitated hand-feeding into the carding machines—one hand to each card. With this machine, however, this requisition is dispensed with. The tow to be carded is sorted and weighed, and then discharged through a shoot onto the table of the machine below. The operator here controls the feeding of the tow into the machine. The material is drawn into the lapper, as it is called, by a sheet and shell feed roller. It is then struck sharply by a rapidly-revolving cylinder, and discharged on to a traveling lattice sheet, which carries it forward to a set of pressing rollers. It is here formed into a large sliver, and is then lapped on to a wood core some 18 inches in diameter. When finished on the core the laps are doffed by hand, the full lap being withdrawn and the new core inserted without stopping the machine. The lap, which is 56 pounds in weight, is placed on a carrier and transported by an elevated railroad to the carding machines and deposited where required. This

lap is then laid on the sheet upon which formerly the tow had to be spread by hand, and the slow revolving of this sheet feeds the tow into the machine, the lap itself revolving as it unwinds its coil. Two of these machines are already in operation at one mill, and here thirty cards are fed entirely by them, only four hands being necessary to attend to the operation, as compared with thirty previously required. Even in this instance only three operators would be wanted if the two machines were installed in the same room. It is stated that owing to the saving in labor and time effected by these two machines, each has nearly repaid the initial outlay in the course of twelve months, while the work is more even and regular than what is obtainable by hand spreading.

SCIENCE NOTES.

According to the information received by the British Admiralty from the officers in charge of the Marine Survey of India, the recent volcanic disturbances which have occurred in various parts of the world resulted in a severe upheaval of the seabed off the Burmese coast. During the early part of December a large island was forced above the water level in the northern approach to Cheduba Strait. It was first seen on December 15 and was then 15 feet above high water. The diameter of the island is about 900 feet, and shortly after its appearance the port officer at Akyab landed upon it, while a scientific survey is to be carried out by the officer in charge of the Indian Marine Survey. The island is probably due to the unrest that has been noticeable for some time past in this vicinity, since in the northwest of Cheduba Island and the volcano, which is in reality a vent for the escape of inflammable gas, has been unusually active.

In a paper recently communicated to the Royal Astronomical Society, Prof. A. Fowler discusses the evidence he has collected for the identification of two strong red lines of silicon with well-marked chromospheric lines. Careful determinations of their wave lengths from a photographic spectrum of high dispersion give the values 6347.31 and 6371.57. The more refrangible line is the stronger in the proportion of 10 to 6, while their intensities in the chromosphere are 25 and 15 respectively. There may have been some suspicion of duplicate origin with a line of iron recorded by Kayser and Rumge at λ 6371.60, but if there is such an iron line it is certainly not an enhanced line. From other considerations of the behavior of the line it appears most satisfactory to attribute it chiefly to silicon. In sun-spot spectra these two lines are almost obliterated, and this feature is in accordance with the general behavior of chromospheric lines. These two silicon lines show the general characteristics of enhanced lines in that they appear close to the positive pole of the arc.

Affinity was first considered as a force, and in this direction it was natural to think of the Newtonian attraction as the chemical agent. So it was that Berthollet, and with far more success Guldberg and Waage, applied the laws of mass action to problems of chemical affinity, formulating a relation still known as the mass law, according to which affinity is proportional to the weight in the unit of volume. Now, as we all know, chemical affinity is of a specific nature, and does not depend on weight merely; on the contrary, the least heavy elements are generally the most active. So Berzelius built up his system founded on the notion that elements have a specific electrical character, either positive or negative, and, in combining, act by electrical attraction. In this direction Helmholtz made a further step in taking into account the quantitative side. Considering the electrical charges involved in Faraday's law, he pointed out as very important that the attraction due, for instance, to the negative charge in chlorine and the positive one in hydrogen far exceeds the gravitational attraction of the masses. Yet a satisfying notion of affinity was not obtained in this way.

The great number of cytological investigations which have been completed within the past ten years indicate notable advancements in a most important field; and this is particularly true with relation to the study of nuclear phenomena. Through this work light has been thrown upon many problems of cell physiology and of development; and as a result of the latter new theories of heredity have been advanced. Nevertheless, the field for investigation has been constantly broadened and many new lines of research made possible. In spite of the excellent results accomplished, there is yet great uncertainty as to the interpretations which have frequently been made. In no field of work, perhaps, is it possible for the personal factor to enter into the results more largely than in this. Again, it is unfortunately true that fixed material has been studied almost to the exclusion of all other and that even general observations relating to the conditions of growth have been omitted in many instances. Much attention has been bestowed upon the minutest details which seem to be of morphological significance in the nucleus; but often the purely physiological side has been insufficiently emphasized. It is quite possible that in different plants, the exact method of chromosome division, or the manner of nucleolar disappearance, may not be similar; and it is certainly well known that external conditions may considerably modify the details of spindle formation, and perhaps other details in nuclear and cell division. The important point in every case is to determine if the same physiological purpose may be accomplished.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

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